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Papers on Hydraulic Engineering. By SAMUEL MCELROY, C.E.

No. 6.—*On the Irrigation of the Valley of Chimbote, Peru.*

The traveler from Panama to Callao, the chief port of Peru, on the South American coast, (from May to November,) after leaving the luxurious vegetation of the Isthmus and the tropical abundance of Ecuador, is surprised and disappointed to find a rocky and forbidding coast for about eight hundred miles of his voyage, and to meet a continual head-wind and the cold Humboldt current which flows from Cape Horn, with the discomforts of a short, uneasy sea and a chilly temperature. Having started with some fear of the effects of a tropical sun, it is strange to meet a temperature much below a New Yorker's summer experience, and to feel the need of an overcoat on deck in latitudes scarcely ten degrees south of the equator. With historical knowledge of the agricultural wealth and fertility of ancient Peru, he is also somewhat unprepared to coast along vast ranges of volcanic hills, and to see the restless surf wash against leagues on leagues of barren and desolate trap-dykes and islands inhabited only by seals and sea-fowls, with the silent and gloomy grandeur of the Cordilleras in the background, barely eighty miles distant, with slopes, peaks, and rough outlines often vividly distinct in the sunlight.

He finds, however, with opportunities for inquiry and closer observation, that the forbidding line of the coast is frequently broken by the valleys of streams flowing from the mountains to the sea, generally into spacious bays and indentations; and that the cultivated parts of the country are confined to these valleys. He also finds that rain-

storms are unknown in this region, and that artificial irrigation is the only process which can be relied on for agricultural purposes. Still further, he is told that few of the mountain streams really reach the coast except at intervals of several years, when fed by an excess of supply, and artificial irrigation, in many localities on the coast, is therefore precarious and uncertain, while always costly and laborious; but, under a law of compensation which nature never neglects, he finds that under adequate irrigation, so great is the influence of the climate and the strength of the soil, that its productiveness in number, certainty, and richness of crops is in wonderful excess of regions apparently better favored.

Having had occasion, during the past summer, to make examination of one of the great valleys of this coast, with a view to its irrigation from one of the chief rivers of Peru, in a district which abounds with evidences of skill of a race which ceased to live and work over four hundred years ago, I have thought a notice of the location, climate, irrigation, productiveness, and methods of improvement would present several features of general professional interest.

The valley of Chimbote is situated in the district of Santa, about 200 miles north of Callao, in south latitude 9° 15′ 38″, and longitude 78° 32′ 51″. It is reached from Lima and Callao by the coast steamers of the English line, running about six times per month, which accomplish the distance, including their stops at various ports, in about forty-eight hours, landing at the port of Santa.

It is bounded on the north by the Chimbote Mountain and its Colorada (red) Range, which separate it from the valley of Santa. On the east it has a range of granite and clay hills which separate it in part from the valley of the river Seco, (dry.) On the south it has a narrow colorada range, which separates it from the valley of Nepenia. It fronts on two large bays admirably adapted to commercial uses as to depth of water, safe anchorage, and easy entrance, and abounding in fish and aquatic birds; of these the Bay of Ferrol is on the north and the Bay of Samanco on the south, separated from each other by a sand spit, with bold head-lands and islands on the sea-front. Ferrol Bay is about eight miles long by four wide, and Samanco Bay eight miles long by five wide. The extreme length of the valley is about sixteen miles, the width of the pampa, or plain, from the bays easterly being about four and one-half miles, in which distance it rises about 100 feet to the level of irrigation. The area which can be irrigated is about 51,000 acres.

The valley of Nepenia, situated on the south, contains considerable population, with the villages of Nepenia and Samanco, and several productive estates; but its fertility is restricted by want of water in the river, which does not flow regularly, or more than once in three or four years. This is also the case with the river Chimbote, a branch of the river Seco, which flows into Ferrol Bay on the northerly side of the valley. The valley of the river Seco, which runs easterly to the foot of the Cordillera Range about 50 miles, contains several villages and haciendas, (estates,) a large amount of stunted trees, valuable beds

of limestone, and abundance of fruit at Lachramarca and Santana. This river, when it flows as far as the coast, runs in part into the valley of Santa on its southerly border. The valley of Santa, fronting on the bay of that name, contains the ancient city of Santa, considerable population, with several very productive haciendas, and is watered by the river Santa, flowing from the Cordilleras with a powerful current and volume, not much affected by the seasons, and having a rapid fall throughout its course.

The Santa river formed the dividing line between the divisions of Peru and Quito in the days of the Incas who immediately preceded the Spanish invaders, and its valley was the scene of the great battle between the rival Incas, which occurred before Pizarro's landing. In riding over the country on surveys it was common to find skeletons and skulls in good preservation, and specially remarked that the teeth of the latter were sound as if pertaining to men prematurely dead, and probably to victims of this civil contest. On the bold hills and on the plains numerous structures yet remain in admirable preservation, as fortresses and temples, built of solid clay walls, with terraces, court yards, walled avenues, and gardens, and exhibiting evidences of great population and of great progress in arts of construction, horticulture, and defence. Other relics from the graves of these people, in cotton cloths, copper work, and pottery work, show great progress in some branches of art. On one side of the lower valley of the river Seco a large ruin exists at a high elevation, from the front of which a set of terraced gardens yet stand in good preservation, with their branch canals for irrigation, fed from the main aqueduct herein described.

The *climate* of this region is remarkably salubrious and favorable to agriculture. From April to November (the winter season) the daily temperature ranges between 67° and 75° Fahrenheit from midnight to noon, and from December to March there is an increase of about 8° at noon, with great uniformity from day to day. No rain-storms occur, but in the winter season, in the early morning, a light shower or rainy mist is common, the rest of the day being clear, with heavy dews at night. A sea-breeze springs up about one and tempers the noon heat. The proximity of the mountain ranges on the east, with the southerly trade-wind and cool Humboldt current of the coast, entirely modify and control the climate, so as to render it peculiarly agreeable to residents and favorable to vegetation. The local scenery is also highly picturesque in mountain backgrounds, fertile valleys, beautiful and tranquil bays, and the bold head-lands and islands of the coast. The atmosphere is very clear and dry, exerting a singularly preservative effect on building materials, animal substances, and otherwise, greatly to the comfort and health of the inhabitants.

Artificial irrigation is required here from the want of rain, and, when supplied, possesses several advantages of operation from the superior regularity of supply and its management.

For the valley of Chimbote the plan of irrigation is simple, being, in fact, a restoration of the great Peruvian canal, which formerly distributed the water from the Santa River over the entire area. This

canal, which has stood not less than five hundred years, was originally about thirty miles long, with a prism of various dimensions at different points, which I propose to reform for an average depth of four feet, and width at the top angles of eighteen feet. It was formed chiefly in the tenacious clay of the locality, protected with a growth of cane, and, notwithstanding a sharp fall of about five and a half feet per mile, which presupposes a rapid current, it stands, as a whole, in admirable preservation. For about sixteen miles in length it is constructed on a difficult location, chiefly along the steep slopes of granite and trap-rock hills, and at a high level above the valley of the Santa River. In some cases the rocks have been excavated by metallic tools or by fire process for part of the prism, but generally the canal bank is formed with a solid puddled wall of clay and stone, sometimes to a height of one hundred feet above its base, with steep slopes, about one to one, sometimes less, and with an amount of labor and an evidence of engineering judgment which testifies in strong terms of the enterprise and civilization of those long departed builders. While the line generally follows the hills, no hesitation is shown in taking advantage of occasional embankments in crossing valleys. One of these, across the valley of the river Seco, was about 1800 feet long and about 42 feet high, and in the next valley the embankment exceeds a mile in length, being curved to suit the ground and avoid extra work. Secondary canals also occur, adapted to special locations; and the intermediate drains, by which the valley below these embankments was originally irrigated, yet remain in all their special details of arrangement, as when the agencies of destruction swept away their constructors. Every step here is among monuments of past skill and taste of no common or modern local rank, and an engineer relearns the common professional lesson, that his calling was magnified in the by-gone ages rather than the present, where "the things which are not teach those which are."

We have observed that many rivers of Peru fail to reach the coast except in extraordinary seasons. This is to be accounted for partly by the absorption of their wide channel beds, but the chief reason is apparent when one has crossed the Cordillera. In the mule tracks which follow the valleys and mountain gorges on the western slope, as in the wild valleys between the Cordillera and the Andes, one cannot but be struck with the care which has been taken to secure even the first outburst of the head sources of the streams, and lead them off, often for many circuitous miles of expensive canals, for purposes of irrigation. In this way, chiefly, the coast is deprived of its natural supply, and without remedy, and the fact furnishes a powerful commentary on the patience and industry of the people, and the productiveness of lands which otherwise would be worthless. After witnessing these primitive works, and after riding more than twenty miles in a line, over the valley of the rivers Seco and Chimbote, now a desolate, open pampa, once teeming with all the luxuriance of the earth, and a vast population, one fords the swift and wide current of the river Santa, feeling a painful consciousness of the wastefulness of the constant and unappropriated stream, whose drops might be more precious than the golden sands of African fountains.

The work of irrigation over this valley is much facilitated by its peculiar formation, as an elongated parallelogram, with considerable seaward slope from the line of water supply. Various productions require various irrigations. Rice needs flooding, while cotton, cochineal, cactus, sugar cane, and other plants require special irrigations eight or ten times per year; and with the regular descent to the bays from the main aqueduct, the intermediate irrigation may be easily accomplished and with great economy of water, while ample power is furnished for the rice mills, cotton gins and presses, and other machinery.

The quantity of supply is assumed at 150 cubic feet of water per acre per day, as a sufficient amount for agricultural use, mills, and waste, and was determined from measurements of the supply of the several canals to the valley of Santa. A draft of 60,000,000 gallons per day will not seriously affect the volume of the Santa River. This supply is equivalent to about one inch in depth of water per working day of ten hours over this large area.

The cost of repairing this old canal is estimated at $185,000, including an item of $45,000 for 150 Chinese laborers, who are preferred, for transfer to cultivation, on the aqueduct completion, the work being estimated to occupy one year. Under the present system in Peru, coolies are much used, being employed under a contract for eight years service. They are paid four dollars a month for their labor, are fed, and have two suits of clothes annually, and they generally prove industrious, sober, good-tempered, and apt workmen, well adapted to the climate and the locality. About 160 are now employed on the hacienda of the Puente at Santa, and seem entirely content with their position. They are quick to learn, acquiring considerable Spanish in three months, and valuable assistants about machinery and mills. The native peons of the back country may be had in abundance at a cost of about sixty cents per day, and have many valuable qualities, being healthy, industrious, and docile, but are less reliable than the Chinese for steady service, and much more improvident.

When this aqueduct is restored to use it will control the hacienda of the Rinconada, and that of the Puente in the valley of the Santa, the pampa of the river Seco, and the great valley of Chimbote. Of these, the first two are irrigated by lower and independent aqueducts, and cover an extent of about 7500 acres, of which about 3500 are now under cultivation. The pampa of the river Seco, containing about 4000 acres, belongs to the Puente and joins the Chimbote Valley. The total area of pampa, from which valuable proceeds can be realized by this supply of water, is about 55,000 acres, and if ever restored, even in part, to the luxuriance of the days of the royal Incas, it will present a scene of agricultural beauty and wealth of no ordinary character and interest, and maintain a large population.

The *productions* of this locality are cochineal, cotton, silk, rice and other grain, sugar cane, fruit, grapes, horses, cattle, limestone, coal, and guano, salt, &c. The Cordillera Range, immediately eastward, is rich in mines of various kinds.

The cochineal bugs, which feed on the common cactus plant, abound

here of the most valuable species, and are easily raised and gathered. From its hardy nature this plant needs very little care and thrives abundantly, its leaves averaging about one pound of bugs per year per plant, with about 1000 plants per acre, which require irrigation several times a year, with occasional pruning. The cochineal is gathered by hand, a Chinaman usually collecting twenty to twenty-five pounds per day. It is then dried and cured by moderate heat, assorted, and packed for market. Recent quotations at Lima were $1·25 per pound, currency, or $1·00 hard money. A production of this valuable character and yield, always in demand at high prices, from so hardy a plant, which has a life of three or four years, being about $1000 per acre, furnishes a sufficient argument for its encouragement.

This region proves admirably adapted to the production of cotton, which was a common article of manufacture among the ancient Peruvians, as appears by the well preserved dresses found in their graves. Various kinds of seeds have been imported and tested, the Sea Island, Indian, Egyptian, and others, but preference is given on the Puente hacienda, to the Sea Island, and Amazonia, (native,) for quality and productiveness. The Egyptian plant is small, but produces three crops per year of good quality. I have seen the native cotton growing at Chimbote without irrigation for four years, of valuable staple, but limited in quantity, as also along the valley of the river Seco, below the Cordillera. The cotton plants require eight or ten irrigations per year, but do not require annual renewal, as in the Southern States. They also give three crops every two years, with an average yield of one pound per plant, having about 1200 plants per acre. Native and Chinese laborers show great aptness in the cotton fields, and the best American gins and presses are now in use, from the impulse given to this article by its great advance in demand and price. A great deal of cotton is annually consumed in Peru, and it is destined to become a prominent place of export, having many physical advantages. While the plants in the Southern States are annually renewed and subject to injury from frost, rust, rot, the cut worm, the caterpillar, and the army worm, the Chimbote and Santa pampas require no cleaning, the temperature is never below 60°, no rain-storms occur, and no destructive insects are known. The difference in shipment to England between Callao and New Orleans will not exceed one-half cent per pound, and there is more than this difference in economy of production, and the market value of Peru cotton at Liverpool is second only to the Sea Island, as appears by recent quotations.

The production of rice and other grain has been amply tested and fully established. About 320 acres of the Puente were planted with rice last spring, giving an abundant harvest of superior quality. This hacienda contains a large rice mill, and sends large shipments to Callao. Wheat and other grain is raised here and in the valleys of the Cordillera in abundance. At Nepenia sugar cane is cultivated with much profit. Below Lima large quantities of grapes are raised, and a superior quality of wine and brandy manufactured. Though not much known in New York, the purity, strength, and flavor of the "Pisco,"

"Italia," and "Muscatelle" liquors are justly celebrated on the Pacific shores. All the tropical varieties of fruits, oranges, lemons, plantains, chirimollas, paltas, figs, melons, &c., are common to this locality.

Very favorable results have been obtained at Santa from experiments with silk worms for two years past. The silk is of very valuable quality, and the mulberry trees grow well without being exposed to the attacks of insects common to other localities. In fact, with regard to the insect life of Peru, the absence of forests and swamps, and the character of all the uncultivated areas, prevent the development of insects as with us, and lands which are artificially irrigated are blessed with an exemption from blight and destruction, in their productions, of great consequence.

Cattle of valuable breed are raised here in large numbers for the Callao market, feeding on the strong grass, (*alfalfa*,) which the grazing fields produce in profusion. All Spanish descendents are particular in breed stock, and the bulls of the pampas and bull-rings are splendid specimens of beauty and strength.

In a country where wagon roads and carriages are very rare, and with a people who are constantly in the saddle, much care is taken with the breed of horses, and the district of Santa is celebrated for its stock. There are about three hundred horses on the Puente hacienda. The saddle horses are all carefully trained and ridden with peaked saddles, heavy curb bits, and large wooden stirrups. The *montura* of a favorite saddle horse frequently costs five hundred dollars, from the elaborate ornaments in silver on its several parts. The gait is an amble or pacing step, trotting horses being rare, and the motion, for the ordinary speed of five or six miles per hour, is peculiarly easy. The horses are fed and watered but once a day, and on the coast are never stabled, and they have great endurance. Valuable breeds of mules are also kept for saddle use, and are preferred for mountain travel, though the Peruvian horses show great aptness for the severe and dangerous passes of the mountain roads, as I have had occasion to observe.

Limestone is found in many parts of Peru of strong hydraulic qualities. I was surprised to find, on the banks of the Santa River, a narrow vein of this mineral enclosed in trap-rock, but still more interested in large veins of valuable gas coal in the same formation. In the vicinity of Ferrol Bay a coal vein exists giving sixty per cent. of gas by analysis, and valued in Lima at twenty-five dollars (currency) per ton. Salt, saltpetre, and guano also are found in large deposits.

Thus, in agricultural and mineral wealth this district possesses latent energies of very great importance, which will promptly repay even partial development, while the commercial advantages of both bays are of equal consequence for imports, exports, and passenger travel. There is abundant room in either Ferrol or Samanco Bay for a large squadron to anchor, and the location is favorable for dry-dock constructions and uses.

The *method of improvement* for pampas of this kind by the formation of haciendas, or estates, and the comparative benefits, may be thus estimated from the basis of local experience.

Assuming a hacienda of 3000 acres, of which 600 are appropriated to buildings, mills, and various incidental uses, and the remaining 2400 applied to cotton cultivation, the investment of capital, exclusive of land or water supply, will be for—

300 Chinese,	$ 90,000
Proprietor's house,	15,000
Chinese house,	5,000
Mills and machinery,	20,000
Carts, horses, oxen, &c.,	15,000
Adobe fences, gates, &c.,	15,000
Superintendence, &c.,	10,000
Investment,	$ 170,000

The annual expenses will be for—

300 Chinese, annual pay,	$ 14,400
Clothing,	6,000
Food,	21,900
Mortality, 5 per cent.,	4,500
6 Overseers,	3,600
Losses on stock, 10 per cent,	1,500
Expenses of proprietor,	4,000
Engineers and mills,	9,000
Contingencies,	5,000
	$ 69,000

If we assume that, by neglect or otherwise, each acre of cotton contains but 800 producing plants, instead of 1200, and that the net yield of baled cotton is three-quarters of a pound, instead of one pound, the annual product will be 600 pounds per acre or 1,440,000 pounds in all, at an average cost, as above, of 4·85 cents per pound. Assuming freight, insurance, and commissions to make 6 cents total, the whole cost of production and sale at Callao is $86,400. At the low rate of 16 cents per pound the net receipt is $144,000 for the hacienda, after a liberal allowance for working force and expenses, or within $26,000 of the capital invested, except for land and water. The actual cash value of an acre of cotton land in this valley is about $60 per year, with sales at 16 cents per pound.

Assuming, however, that but 30,000 acres, or three-fifths of this valley, are cultivated, and that the annual increase per acre is but $50, the annual value of the patent will be $1,500,000 to those who operate it directly or by leases. This estimate does not include the productions from coal, guano, commerce, and fisheries of the bays and other sources of income.

If, on the other hand, we disregard the idea of cultivation, and irrigate the lands for sale, and assume so low a rate as $50 per acre for net receipts, the intrinsic value of the patent is $2,550,000 in return for an investment of less than one-tenth the sum.

From the limited number of reliable rivers on the coast line, irrigated property is in great demand in Peru, and fabulous sums are said to have been spent, at times, to supply water under difficult circumstances. The income, however, justifies a liberal expenditure, and the market is always sure for what is produced. The books of the Puente

hacienda show a return of $130,000 the present year, for an expenditure of $26,000, on a cultivated area of about 2400 acres, and on an estate where cochineal and cotton are but recently introduced, and, as yet, but partially planted. Nor have the hacienda proprietors availed themselves of the various labor-saving devices of our own country, which may be readily transferred to Peru.

A few months' experience of this region, as to its admirable climate, cheap labor and productiveness, and its facilities for expansion, in the immediate vicinity, also of very valuable silver mines, which exceed those of California in convenience of access and economy of food and labor, impressed me with a strong conviction of its comfort as a residence, and its promise of direct recompense to any judicious investment; and the people, as an entire class, are specially courteous to citizens of the United States, whom they regard as members of a powerful republic, on which, in more than one sense, the stability of their own depends. The occasional revolutions of Peru have no commercial consequence to foreigners, and are chiefly their inconvenient methods of presidential elections, in which neither ballots nor bullets have any prominence, and very little public or private injury is effected.

As an illustration of the spirit of the Peruvian government towards our citizens, we have a sufficient evidence in the grant of a patent covering the valley of Chimbote to New York capitalists, who now propose to irrigate and develop it, and who hold it under the strictest forms of Spanish law, and who also hold the right to open and work several of the richest silver mines of the Cordillera, about eighty miles east of this valley.

Iron-cased Sea-going Turret Vessel.

From the London Artizan, January, 1866.

The possibility of constructing armor-clad ships of moderate size, to carry heavy guns without sacrificing speed and sea-going qualities, has been repeatedly discussed in Parliament and elsewhere, and is a question that is occupying the attention of all who are interested in the development of our naval resources and the construction of the iron-clad fleets of the future.

Messrs. Laird Brothers, of Birkenhead, have just completed a vessel which, from her performance on trial and general appearance, bids fair to fulfil these conditions. She is an iron vessel of 1100 tons and 300 horse power, with a speed of more than twelve knots an hour on a draft of water of 16 feet, throwing a weight of broadside of 600 lbs. from her turret, besides carrying two 40-pounder rifled guns on the quarter-deck. The dimensions of the hull are about 200 feet extreme length, 35 feet breadth, 20 feet deep, and 1100 tons measurement. The hull is of iron of great strength, and is divided internally by bulk-heads into water-tight compartments, so as to enclose her turrets, engines, boilers—all her vital points, in fact—in separate compartments. In addition to this provision for the ship's security, there is a double bottom under the engines, boilers, turrets, and magazines, extending up to the lower

deck. The armor plate is 4½ inches thick, extending from her upper deck to 3½ feet below the load water-line slightly tapering towards the bow and stern, to lessen the tendency to pitch in a seaway, and rests on teak backing 10 inches thick. The accommodation for the officers and crew is of a very superior description, well ventilated by means of skylights and side scuttles, and there is free communication from one end of the ship to the other by iron sliding doors on all the water-tight bulk-heads. The spaces in the store room and magazines are ample for the stowage of six months' provision and ammunition. The turret is cylindrical in shape, covered with armor plates 5½ inches thick, and is placed before the engine room, and is fitted with slides and carriages for two 12½ ton 300-pounder guns on the system of Captain Cowper P. Coles, R. N. The rig of the ship is that of a brig, the foremast being fitted as a tripod on Captain Coles' patent, to give greater range of training to the guns in the turret. The engines of the ship are 300 horse power nominal, having cylinders 54 inches diameter, 3 feet stroke, driving a four bladed screw propellor, 14 feet 9 inches diameter, 17 feet 9 inches pitch. The cylinders have steam jackets and improved expansion valves. The trials of speed were made at the measured mile, and gave, as the result of four runs, a speed of 12·27 knots an hour. At the time of these trials the vessel was completed in every way except guns and sea stores, and had 100 tons of coal in the bunkers. The mean draft of water was 14 feet 3 inches; the engines made 78 revolutions, pressure of steam 25 pounds, vacuum 26 inches, indicated horse power 1650. The engines worked very well, and the boilers gave an abundant supply of steam. The ship was quick in answering her helm, and her steering arrangements are excellent, having one wheel in front of the poop and the second under the pilot tower forward.

This we believe is the greatest speed ever attained by an iron-clad vessel of this size, and bears out the statement made by Mr. Laird in the House of Commons, in the discussion on naval estimates in March last, that it would be possible to build vessels of this class to have a speed of 12 knots an hour, and the recommendation of Mr. Stansfeld, M. P., that the government should seriously consider the importance of constructing small fast vessels, carrying one or two heavy guns, at a high rate of speed, as, in his opinion, tending to increase our means of defence, and keep down the costliness of the naval service of the country.

For the Journal of the Franklin Institute.

Increasing the Speed of Steamers—Form of Propelling Blades—The Oar and Paddle.

To find out and properly employ the mechanical laws or principles impressed upon matter are among the leading purposes of our physical existence. Progress depends upon our knowledge of them, and in order to this, creation abounds with, or rather consists of, endless illustrations of them. Experimental philosophy has been deemed an employment worthy of angels, for, though treated as a secular busi-

ness it has the elements of a religious performance, for physical truths are as sacred in their origin and beneficent in their purposes as those of ethics, and seeking to discover them by experiment is an appeal to the Creator as direct as that of mental prayer for moral light. The form of invocation is the most consonant and when properly made is never in vain.

While few persons have the means, the taste and aptitude to carry out a series of costly experiments, there are cases where national resources may with propriety be drawn upon for the purpose. A nobler use of public money perhaps never can be made than to eliminate laws of the generation and application of inorganic forces. The current experiments of the Navy Department on steam are of this character, and, as elsewhere remarked, if wisely planned and executed, they will be of immediate and lasting advantage to the world. They ought not, however, to stop short of determining the plan of propulsion, which with a given power produces the greatest speed. Economy in the evolution of force is of little avail if what is saved be wasted in the application. It need hardly be stated that such experiments should not be given in charge to interested or contending parties. Nature—a metonomy for the Author of nature—listens only to sincere and patient inquirers. She has no answers for excited litigants.

Some things are overlooked by naval engineers. I think so, because I hold it an axiom that wherever persevering efforts to improve an art fail, some point or other has escaped notice or its importance was not suspected. Innumerable attempts, and at a fabulous expense, have been made for over half a century to increase the speed of steam vessels, with little or no marked success, and, what is to be regretted, the lesson which the failures inculcate is ignored—that art is the similation of nature, and nature the climax of art. A profound conviction of the perfection of nature's mechanisms is the surest presage of success with ours, for when carefully studied there is no difficulty in detecting wherein we are wrong. Our engineers have not done this. They have not consulted natural propellers. Perhaps they did not think of them; or, it may be, they deem the principles of their action different from those they depend on. If so, they overlook the fact that those given us to work with are the same as the Creator employs—that there are no others.

In every branch of the arts talent is respected and expectation of their advancement pervades the general mind. A new propelling apparatus by a distinguished savant would draw crowds to behold it, and were it possible for a mechanical genius from a neighboring planet to give us a course of lectures on propulsion, with transmundane illustrations, who would stay away? Yet, strange as it is, we have continually before us working models in great variety from the hands of the Great Engineer himself, and give them no attention, as if He who formed the eye cannot see. We act as if the Author of forces does not best know how to apply them, and fondly imagine we can attain better results by deviating from principles He has established. The only excuse for this is, we are yet as children entering a school with little or

no ideas of what is to be learned in it. Engineers are but in training for the work before them. They do not yet know that the truest embodiments of mechanical laws are, and forever will be, those of nature, and that there can be no applications of science which she has not anticipated. As a class, the lesson is in advance of them. Occasionally one has recourse to the living volume when dead pages and diagrams in books fail to meet the exigence; but such are solitary cases—presages, however, of a legion in due time. It will then be with the mechanical student as with the lover of natural history, when, sick of artificial systems and dicta of schools, he exclaimed: "I do not want to hear the harangue of the exhibitor; I want to behold the exhibition itself."

Let any one thus act and he will find—1. That in nature speed does not depend so much on dimensions as on the form of the propelling organ; hence, to change slow into swift movers it is not enlarged—it is often diminished—but the outline is changed that it may take a deeper hold of the fluid medium. This rule is absolute and so fully and variedly elucidated that there is no mistaking it in aerial or aquatic propellers. Our practice is in direct opposition to it.

2. In no case is the organ of one width. There is nothing like the horizontal parallelograms of the buckets or floats of our steamers. To gain speed the width diminishes from the widest part to a pointed extremity; that is, the shorter and broader the blade the slower the speed; and the converse, the longer, and tapered, and pointed, the greater the speed. This is so universally true that as naturalists detect in a single scale of a fish the species or genus to which it belonged, with equal certainty does the detached wing of a bird or tail of a fish indicate its relative velocity through air or water.

3. In no instance does a large sheet of wing denote rapid flight, but often the reverse. A certain amount of surface in one form produces double the effect in another. Of birds of the same average weight of body and wing surface, some are indifferent and others rapid flyers. The difference is caused by the removal of a portion from the width of the former's wings and adding it to the length of those of the latter, as may be seen in domestic fowls and wild ducks, and more obviously in sparrows and swallows. Some wings are scarcely half as long as the body, others equal it in length, while in the swiftest it often extends beyond the tail.

It is the same with occupants of the liquid ocean. Short, rounded, and triangular caudal fins are slow movers; lobated and pointed, without increase of surface, the quickest. The difference is due to the removal of a portion of the wide extremity of the former and adding it to the parts left, thus forming the nuclei of lobes. As the indentation is deepened and the lobes extended, speed increases, from the sole to the mackerel, the dolphin and the sword fish supposed to surpass in velocity all others. An additional and interesting proof of the principle is furnished in the class of unequal or heterocercal lobes; the longest giving additional speed in the direction, up or down, most essential for seizing prey or escaping from danger. And further, when

the material of both lobes is absorbed in one, as in the thresher or long tailed shark, the blade, as in some birds, being longer than the body.

As the loss of power from the inequality of pressure on steamers' buckets is not perceived, no attempts are made to avoid it. Every part meets with a resistance that increases with the distance from the shaft, because velocity or space passed through thus increases. It is as when a door is thrown open, the resistance of the air increases from the hinge to the handle, because the parts adjoining the latter are forced through three or four feet of the fluid, while those near the former move only as many inches. This result is unavoidable in rectangular blades, and in it we perceive the reason why nature forms none. In her swift propellers there is an equality of pressure on every section, and the centre of resistance, instead of being, as with ours, at the extremity, (which would break the wing-bones of every rapid flyer and paralyze the caudal fins of the shark and sword fish,) is in the middle of the blade. The simple and beautiful way in which this is done—simplicity is the acme of beauty—affords one of those instances that set the minds of philosophers aglow with admiration of nature's devices. By *tapering them, equal transverse sections, however varying in extent of surface, have equal power.* The tip of a wing being as efficient at the widest part—diminished surface being compensated by increased velocity or extended sweep.

But waste of power from inequality of pressure is not confined to buckets when in the water. It equally attends them when out of it. The resistance of the air as they are whirled through it, is greatest towards and at their outer edges, and therefore acts with the greatest effect. The number of horse power thus consumed in large steamers to no purpose but to retard their progress, I do not remember to have seen stated, nor, in fact, any reference to this source of loss. To what extent it would be reduced by the substitution of vertical, tapered, and pointed blades for ten or fifteen feet horizontal planks may be imagined. The loss of power from this cause in the oar is felt and sought to be avoided by feathering. How much more important, then, to guard against it when the blades are so many times larger and worked with greater velocity.

I have been asked by readers of the article on "Expansion and Propulsion," in the November number of the *Journal*, what form of blade is proposed, and have answered by referring them to the illustrated papers on the subject in Patent Office Report of 1849, the article on the "Influence of Form," in the *Journal* for 1855, and to another in the *London Practical Journal* of December, 1859. I was in hopes the subject would have been taken up before now, if not by the Institute, by some one of its mathematical correspondents. Till the law of configuration of blades be laid down and impressed upon practical men, fresh forms will continue to be offered like ventures in a lottery in hopes of obtaining the prize by chance. As a further attempt to draw attention to it, a few more pages are added.

Though differently applied, I suppose the true outline of the oar and the paddle the same, and that the like form and proportions are

equally fitted for steam vessels as for boats and canoes. It is singular that so little attention has been given to the oar by competing boat-clubs, and not by them alone. I do not know any modern dictionary of the arts or encyclopedia that has an article on it, except *Chambers*, now passing through the press. Without explanation, the annexed outline is said to combine greatest power and lightness. It appears to be a fair representation of the European and American oar. Still there are many blades that slightly widen to the end.

Pliny assigns the oar to two towns in Bœotia. The Copeans devised it, but the Plateans invented the broad and flat end. That was the Greek story. The implement doubtless dates from times anterior to the colonization of Greece.

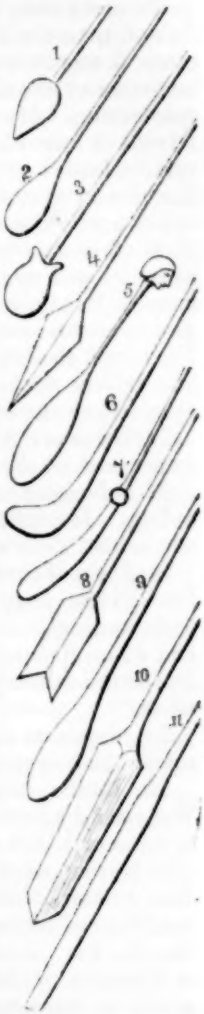
It is worth observing that the aboriginal paddle of the Eastern was also that of the Western hemisphere. Indians on the lakes, the St. Lawrence, Mississippi, Orinoco, Amazon, and the Plata used the same type of blade as boatmen on the Nile, Euphrates, Tigris, and the Indus. If there were not more virtue in it than in others, how came it to be adopted where the arts were most cultivated? Certainly not for lack of investigation, but from a conviction of its superiority. For there is abundant evidence that propelling blades were more the subject of inquiry and experiment with advanced nations of old than in modern days, and, as some think, a nearer approach to the true form attained. Contrary to our practice, the resistance did not converge towards the end of their blades, and consequently required less expenditure of power to overcome it, an advantage impossible with ours.

In direct conflict with us, the Assyrians, the Egyptians, and the whole ancient world, rejected the parallelogram except for rudders, nor was it, nor is it, always adopted for them. To avoid its defects, or for other reasons, they preferred curved outlines, which veered between the ellipse and heart shape, or that of the common palm-leaf fan. Both occur in the sculptures, and are, with the oval, as much in use now as ever. The oar of the Egyptians, observes Wilkinson, (Manners and Customs of the Ancient Egyptians, vol. iii., first series,) was a long, rounded, wooden shaft, to which a flat board, of oval or circular form, was fastened; and it is remarkable, he adds, that the same is now used on the Ganges and in the Arabian Gulf. Dr. Pickering (Races of Man) says the oar of the Persian Gulf has a circular blade, which he met with at Mocha, Singapore, and Manila, and in the Tarrawan Islands.

A few figures representing varieties of the oriental oar, the Roman and European one, and paddles, the parents of the oar, will add interest to the subject.

No. 1. From an Egyptian vessel of 16 oars represented on the walls of Medinet Haboo, at Thebes. The modern Kellek of the Nile, a raft supported on inflated skins, is kept, says Bonomi, in mid-stream by two rude oars, with blades the figure of a palm-branch fan. Similar ones are represented with Roman vessels. The ornamental rudders

on coins and figured in the hands of deities, appear to have been derived from the same source.



2. Wilkinson gives several vessels propelled by the oval and ellipse, and forms veering between them. There are six oars to each side of the vessel from which the figure is taken. The rudder is a large oar resembling ours. The rowers stand with their faces to the stern. This form of the oar is as common on the Amazon as on the Nile and the rivers of Assyria and India. (See Edward's Voyage up the Amazon: New York, 1847.)

3. From a war galley of 20 oars. The enlargement of the upper end of the blades was probably adapted to some peculiar mode of fastening them to the shafts. The rudder similar to No. 2.

4. A large sail-boat; has 22 oars of this pattern on each side. The rowers have their faces to the bow, and push instead of pull. She is steered by three similar blades. This spear-shaped oar is a proof of mental activity in nautical devices. It shows that researches on the form did not terminate on the Nile, with elliptic types, where speed and economy of power were required, as they obviously were, in galleys of forty to fifty oars, like the one represented. Had these blades been of steel, and the weapon and oar united, such vessels would have been doubly armed. Nor is there anything improbable in the idea, since ninety camel-loads of pickaxes, pointed with *excellent steel*, have been found in a chamber of the palace of Khorsabad—an item of ancient war material.

Fosbroke refers to one of the Hamilton vases for an Etruscan acute-angled oar, tapering, like a pyramid, from top to bottom. He is mistaken, for the blade is not shown at all. Part of the shaft only is figured, about two inches wide where the hand grasps it, and wider where it enters the water. The oar of galleys are commonly thus represented, the blades being out of sight. See the French *Encyclopédié* for similar figures.

Whether the *paddle* is now used on the Nile, we know not, but that it was once a popular implement, appears from its oft recurrence in the sculptures. In the large volume of Denon it is figured some fifty times, varying in dimensions, but uniform in shape and proportions.

5. Is from the portico of the Temple of Tentyra. The handles of all terminate with a head. (In the figure it is made too large.) The blades are fac-similes of those of American Indians and Pacific Islanders, and, like them, were sometimes ornamented by carving, of

which an example is in Plate 132. This paddle occurs thirty or more times on the famous Zodiac.

The Assyrians appear to have modeled the oar after a different fashion than the Egyptians. Instead of the blade being a separate piece, it was narrowed and lengthened so as to be, as with us, a prolongation of the shaft. Another feature is its curvature; one worth considering. Mr. Pickering says the paddle of the Disappointment Islands is curved. In the Nineveh Sculptures are marine scenes; vessels loaded with and towing heavy timbers, propelled by four to five oars on each side. In some the rowers stand facing the bows, and consequently push the oar from them. No. 6 is from the thirty-first plate of Botta's splendid work. Some blades are narrower and not near so much curved. Of one vessel, (Plate 35,) the whole four vary more or less in dimensions and conditions, as if collected for an emergency, or the owners too poor to obtain a regular set. One resembles No. 9, and the blade of another is shattered and broken. In Plate 32 one of four blades is also represented as half worn out—incidents recorded by the sculptor that give additional value to the tablets.

7. There are Assyrian oars resembling this, but it is from a Norman vessel on the Bayeaux Tapestry.—Fosbroke ii, 226.

8. Belonging to a Saxon ferry-boat on the same plate as the preceding. It might be supposed to have three blades, two in action and one behind them as a rudder. Possibly a defective representation.

9. From Valturius on Military Affairs, A. D., 1483, printed in Paris, 1532, page 315. This blade is represented as Roman. It has been continued more or less in use by Latin races. See Plates 12 and 31 on Fishing in *Encyclopédié*. It was the English oar in the fourteenth century.—See boat tilting in "Strutt's Sports and Pastimes."

11. Japanese oar from Perry's U. S. Japan Exhibition, i., 450. A similar blade appears in the French *Encyclopédié*.

10. Roman, from Stewichius' Commentary on Vegetius, MDCVI. The same blade is given in Hartman Schopper's Illustrations of Professions and Art in Europe, in the middle of the sixteenth century. The figures, singularly accurate in detail, are by the famous artist, Jost Ammon, 1568. The oar does not occur in the hundred plates of the Stradas, but is twice figured by Ramelli, in 1588, and precisely like No. 10. It is figured in the *Dictionaire Universal Mathematique et Physique of Saverien*, Paris, 1753, (Plate 48,) with an elaborate article on the oar, to which the Encyclopedists refer.

Taking it for the common Roman blade, it deserves more than a passing notice, because old warlike nations gave, and with reason, special attention to the oar. Simple as it appears, naval conflicts were principally decided by it. Vegetius, on the manœuvres of a fleet, says: "The essential qualifications in the captain is vigilance; in the pilot, skill; in the rowers, strength. Naval engagements are fought when the sea is calm, and the ships, not moved by the wind, depend entirely on the force of the oars, either to attack the enemy's ships with their beaks, or, in their turn, to avoid the shock. In these movements,

it is strength of the rowers and the dexterity of the pilot that generally decides the victory."—Clarke's Translation.

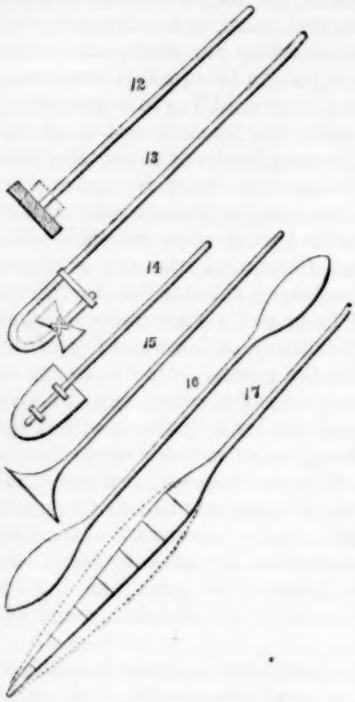
Not only for speed to avoid or overtake, but for momentum as rams to sink an enemy, vessels depended on their oars, hence the policy of increasing their number, first, by lengthening the hulls, and when that feature was exhausted, by widening them to admit of two rows, or benches, or banks, on each side, and thus doubling the propelling power. National rivalship next extended this feature, and to an extreme. A Corinthian built a galley of three banks or rows; the Carthagenians, not to be outdone, fitted some with four; Syracuse then sent them out with six, and at length the number rose to ten. Alexander is said to have had galleys with twelve rows on each side. Ptolemy Soter built one with fifteen; Demetrius, the son of Antigonus, and an expert mechanician, increased the number to thirty. Another of the Ptolemies built one of forty and his successor another of fifty. No doubt both were splendid failures, and in not a few of the others the tonnage must have exceeded the power. How ten rows of oars could be efficiently worked on each side of a vessel, raised above and extending beyond one another, is all but inexplicable, and but for the gigantic achievements of ancient engineers in other departments of the arts would be incredible. One thing is, however, certain—that the oar, worked by men, was employed in naval warfare to an extent that will never be equalled. At Salamis it drove Xerxes out of Greece, and it may be said to have given the empire to Octavius, for it was the superior agility of his galleys at Actium that gave him the advantage over the larger and heavier armed hulls of Antony and decided the victory.

Antony had recourse to a popular supersfition to cover his defeat, and, what is singular, Pliny, himself a naval commander, gave credit to the ruse. He says a remora arrested the admiral ship during the battle and neutralized the utmost attempts of the oarsmen to move her! He confirms this by quoting a case within his own recollection, that of the galley of five banks of oars that conveyed Caligula the last time to Rome. She was suddenly stopped by the same little fish, "notwithstanding there were four hundred lustic men that labored with the oars." Taking that number as the proper complement of a five bank vessel, the crews of some of the vessels of Demetrius and the Ptolemies must have amounted to thousands.

What the oar was, it still is in its modern substitute in steamers—a great disturber of nations. Of the paramount importance of speed, reference need only be made to the success of foreign blockade-runners in the late war and to the destruction of unarmed and unresisting ships and their ladings of merchandise by the British armed corsairs, *Alabama* and *Shenandoah*, that has shocked the moral sense of the world.

It would appear that not till modern times was the oar constructed as it now is in Europe and with us. The end was invariably rounded or pointed. It should, however, be stated that among the Assyrian tablets in the British Museum representing naval scenes, there is one in

which the blade was apparently designed to apply the principle of accumulated resistance at the end to the fullest extent. A parallelogram, of about eight inches by two, was attached to the paddle or shaft crosswise, like a crutch or inverted T. (See No. 12.) It is obvious that such a blade would have more hold on the water than one four inches square, indicated by the dotted lines. Probably they were used chiefly as rudders, and the emergency called them into action as oars on the occasion represented. This would accord with the minute attention of the artists to details, examples of which have already been noticed. As this blade resembles in its outline our steamers' buckets, it may here be remarked that some years ago the depth of those of one of our large vessels was reduced by removing four or five inches from their upper edges without affecting her speed. This fact I had from the late Mr. Stillman, the eminent founder of the Novelty Works, by whom the change was made.



13. Another oar, from a slab in the Kouyunjik gallery in the British Museum, which may as well be added, though the reason for the form and the material employed are left to conjecture. The artist represents wicker boats on the Tigris, similar to those still used on that river, each impelled by four men with oars of this singular construction. That it had some advantages may be presumed. Its introduction in historical tablets afford another proof that there was more thought and invention expended on the oar by ancient boat-builders than their modern representatives can boast of. See Bonomi's "Nineveh and its Palaces."

The remaining figures are from Wilkes' U. S. Exploring Expedition.

14. From the Kingsmill Islands, v., 49. The men are expert in managing their canoes, but their paddles are miserably made of cocoanut board or tortoise-shell, about six inches square, attached to a round stick.

15. Steering oar of the Paumotuans, Southern Pacific, i., 327, 345. An interesting example of intensifying the resistance at the extremity of the blades, in which respect it is related to No. 12, and to our steamers' buckets.

16. The Sooloo paddle, Indian Ocean, v., 333.

Dr. Pickering mentions it: "As we proceeded along the coast, many small canoes came around, having double out-riggers and double-bladed paddles." The same form is figured with the common Tahitian canoe, ii., 21, 36, and is that of Greenlander's double-bladed paddle.

The oar of the Spice Islands struck the Spaniards and Portuguese as a singular one. Speaking of Banda, Argensola (Discovery and Conquest of the Molucco and Phillipine Islands) says: "The slaves ply the oars, which are like wooden shovels; they make the vessel fly by main force, and serve to lade out the water when there is occasion. The figure is not given.

17. Fuegian paddle, i., 116, 123. Remarkable as being the longest and narrowest of blades, straight sided too.

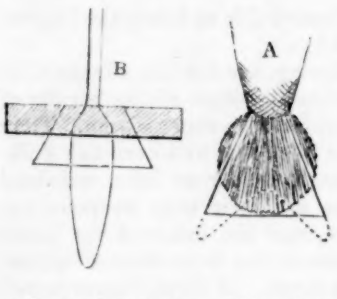
The Magellenic waterman, says Pickering, are far less advanced in the art of navigation than their northern brethren of the Straits of De Fuca; their canoes are smaller and inferior in construction. They are not known to venture forth into the open sea, and even the Falkland Islands, although so near the coast, appear to have remained unvisited by them. Slings and spears are their only weapons, the strings of the former being animal fibre, and the heads of the latter bone, in shape and attachment analogous to the bone-pointed arrows and salmon spears of the northwestern coast. A further unexpected analogy is perceived in the shape of the paddles, the Fuegians making the blade even narrower than do the northwestern tribes.

Viewed either with its straight sides or their expansion into the elliptic form, as per the dotted lines, unless I am greatly mistaken, this blade approaches nearest of the whole to the true one, to that which with a given power produces the greatest effect. Equal transverse sections, (as marked,) though unequal in area, are equally effective, and the centre of pressure is near the middle. Such is the principle invariably adopted by nature. Without it there had been no rapid flyers and swimmers, and without it all our efforts to gain speed must forever fail. If this blade is the best for canoes, it is the best for steamships, which are merely large canoes. The wing of the condor is but the humming bird's enlarged, and so it is with the propelling fins of the whale and the minnow.

Is it asked, How came the most wretched of American aborigines, a people wholly destitute of clothing though living near the Antarctic Circle, by this blade? How account for this and for the general uniformity of thought among barbarians of other lands on the implement? By that which is as essential to guide man ere the reasoning powers are awakened, as to the lower tribes, *instinct*, as it is called, and but for which our species had early perished. Without the resources of art, savage man lives close to nature, depends wholly upon her, and is governed by her unerring suggestions. By her he is led to mechanical devices as birds are to build nests, wasps to make paper, and bees to practice geometry. He is, as it were, intuitively and unwittingly led to adopt principles which in civilized states are only recognized and realised after long observation and much blundering in wrong directions. Other aboriginal things might be mentioned, and the Te-

piti or Cassava Press among them, that put to shame some of our costly and complicated contrivances. It is thus that people the most enlightened may take lessons from the most ignorant. The steam fleets of the world may be benefited by the paddle of barbarians.

The progressive stages of natural speed, each starting with the initiation of a new feature in the blade and increasing with its development, will be better understood by aid of the diagrams A, B, than by words alone. The shaded circular fin of A represents that of the sole and some of the slowest swimmers. To meet the requirements of more active classes, it undergoes successive modifications. The sides gradually straighten, the end widens, and its convexity depressed till the outline becomes that of a truncated pyramid or triangle—the terminus of the second stage. Then for swifter, and up to the swiftest movers, another change begins which neither human art nor science could have anticipated. A portion is removed from the middle of the base line of the triangle and added to its end as lobes. (See dotted lines.) The *power of the blade* now *increases with the depth of the fork and length of the lobes*, and even still further, by merging both into one, an instance of which has already been quoted. (See also Plate 3, of Patent Office Report of 1849.)



Such is the virtue of *form* and of form alone, for the three blades in the diagram are equal in area—the same amount of surface in different shapes—while the centre of resistance in the last form is in the middle of the blade.

This appears to be nature's ultimate type of propellers—aquatic, aerial and amphibious—and therefore the most perfect of patterns for us to study. It is impossible for human ingenuity to equal it. When once engineers adopt it, they will be conscious of possessing the means of attaining not only the higher, but the highest rates of speed, with harmony of motion and economy of power. A new epoch of navigation will begin with it. Steamers, instead of resembling organisms, whose blades make more noise than dispatch, will rival the flight of the frigate bird, whose power, extent of wing, and oceanic range constitute it the eagle of the sea. Limited as we are neither in power nor in propelling surface, there is nothing wanting to effect this but to give the true form to that surface.

Such is the Creator's plan. Now look at ours in the shaded blade of the diagram B, a long, horizontal parallelogram, antipodal in form and action to any in nature, and vastly inferior to the rudest ever proposed. It is so outré, that its adoption seems rather a result of accident than reflection. An Indian adrift in his canoe, or a sailor in like circumstances, might work his way with it, but not for a moment would either use it as we use it. Both would unhesitatingly plunge it end-

wise into the water. Instinct would lead them thus to take good hold of the fluid near them, instead of extending the board laterally for a weaker hold further off, and requiring greater labor to get it.

Cut the board into three pieces and unite them as in the diagram and the propelling power will be greatly increased, but not near so much as is now required. As at A, the triangular form should be considered the basis of a better. In nature it is chiefly confined to a few small fishes. In larger ones it is invariably forked. The third stage for us is therefore the same as in nature, the horizontal plank must become a vertical lobe. Is it asked, Why not two lobes as in swift swimming fishes? because the organ in them is designed to answer the purpose of dual blades in birds, and paddle-wheel steamers, like them, have propellers at each side.

An impression prevails among some men that it may be all very well to talk about nature in books, but that it will not do to follow her as proposed, because her propellers are so different from ours in their materials, their functions, and forces. They misunderstand the proposition, or do not give it due consideration. If they admit that natural mechanisms are perfect expositions of mechanical laws, they have misgivings about the action of the same laws in artificial constructions, as if levers of bones and cords of sinew act differently from those of metal and flax. As we can no more alter or affect one of the laws of force and motion than create matter, all that we have to do, or can do, is to construct our machinery in accordance with them, and that is what is meant by imitating nature, not, as some would affect, to make our locomotives run on feet. And where is there a law or principle more clearly illustrated and enforced in nature's repository of mechanical marvels than that which makes the speed of bodies moving through fluids to depend on the taper and length of their propelling organs.

In lightness and flexibility natural blades are unrivalled, but for our purposes those of inorganic materials are better than any of living tissues, and so is the continuous rotary movement we give them than the alternating action of natural ones.

As the world is more governed by custom than by reason, time is required to loosen its hold in mechanical as in other matters, and the more so when large interests are involved. This is right. It is not to be supposed that proprietors of ocean and river lines of steamers, or the government, can be led to introduce changes in propelling machinery which their professional advisers do not endorse. Still, whenever sufficient reasons are adduced which render an experimental test expedient, it surely is the part of prudence to have it made. The cost of changing the blades of a vessel for one or two trips is hardly worth considering in view of determining the form of blade in which efficiency and economy of power are pre-eminently combined.

To initiate the proposed change, a medium blade between Nos. 10 and 17 might be adopted. By it the width of the present wheels would be reduced four-fifths if not more, and if the diameter be nominally it would not be virtually enlarged, as the real radius would be

from the centre of the blade to the axle or shaft. In new vessels it might be reduced, as there would be no necessity, as now, to place the shaft so high above the water. Instead of the edges of ten or twelve foot planks brought slap down upon it, the pointed ends of the proposed blades would silently enter it. Whenever a machine is on a wrong basis, minor movements are brought in to uphold it that increase the wear and tear and consumption of force. On a true one, the principal and adjuncts are in union and the work done with a minimum of power. As in the present case, any objection brought against it tends, when examined, to confirm it; thus, it has been intimated that the velocity of the present wheels might be too great for blades of the proposed dip. Supposing, but not admitting, some truth in this, the speed of a steamer no more depends on the rapidity with which her blades strike the water than that of a bird on its wings striking the air. She may double her revolutions and go slower. With fewer steps, the lad on stilts outstrips his associates on the ground, but turn to true exemplars, and the rule will be found to hold that lengthened blades with *diminished velocity* increases speed. Thus the laborious flutter of the partridge is exchanged for the easy and silent sweep of the eagle and hawk. Our steamers, with their clattering buckets and tremor, resemble the former instead of the latter. But marine propulsion is in its infancy, and the science of natural forms has not left the cradle.

E.

New York, December, 1865.

Experiments on the Strength of Cement, Chiefly in reference to the Portland Cement used in the Southern Main Drainage Works.

By JOHN GRANT, M. Inst. C. E.

From the London Civil Engineer and Architect's Journal, January, 1866.

This commmunication related to an extensive series of experiments, the results of which were recorded in voluminous tables forming an appendix to the paper, carried on during the last seven years, with a view to insure, as far as possible, that only cement and other materials of the best quality should be employed in the Southern Main Drainage Works of which the author had charge as resident engineer.

As a preliminary step, samples of Portland cement were obtained from all the principal manufacturers for the purpose of experiment. The average weight of these samples were found to be 108·6 lbs. per bushel, and they sustained breaking or tensile strains at the end of a month, varying from 75 lbs. to 719 lbs. upon 2¼ square inches. A clause was then inserted in the specifications to the effect that the Portland cement to be used in the works should be of the very best quality and ground extremely fine, weighing not less than 110 lbs. to the striked bushel, and capable of resisting a breaking weight of 400 lbs. upon an area 1½ inch square, equal to 2¼ square inches, seven days after being made, and after being immersed in water for the whole of that time. The standard was subsequently raised to 500 lbs. on the same sectional area, which was that used throughout the experiments. During the last six years 70,000 tons of Portland cement had been used in these

works, which extended over a length of 18 miles and had cost £1,250,000. This quantity of cement had been submitted to about 15,000 tests, at a cost of only five farthings per ton. The machine devised for showing the tensile strain was a lever balance constructed by Mr. P. Adie, (Assoc. Inst. C. E.,) and its first cost was from £40 to £50. It was so simple that an ordinary workman could be trusted to test the cement, and the cost for labor did not exceed £80 per annum for each machine.

The manufacture of Portland cement required extreme care in the admixture of its two simple and well known ingredients, clay and chalk, it being necessary to vary the proportions according to the quality of the chalk; thus, in white chalk districts, the clay formed from 25 to 30 per cent., and in grey chalk districts from 16 to 20 per cent. of the whole bulk. The manufacture was carried on almost exclusively on the banks of the rivers Thames and Medway; the clay, which should be as free from sand as possible, being obtained from the creeks and bays between Sheerness and Chatham. Long experience now enabled the clerks of works and others to detect the qualities of the cements by color and by weight. Very strong Portland cement was heavy, of a blue grey color, and set slowly; in fact, the longer it was in setting the greater was its strength. Quick-setting cement had generally too large a proportion of clay in its composition, was brown in color, and turned out weak, if not useless. In the first schedule of prices 2*s.* 3*d.* per bushel was inserted; but this was far above its present market value.

But the tests were not alone sufficient. It was essential that constant supervision should be exercised to insure that only clean and sharp sand should be mixed with the cement; that the cement was only supplied with sufficient water to reduce it to a state of paste, which was best accomplished by means of a perforated nozzle at the end of a pipe or watering can; that the bricks or stones were thoroughly saturated with water, so that in setting the cement might not be robbed by absorption of the moisture necessary for its perfect hardening; and that a current of water was prevented from passing over the cement, or through the joints during the progress of setting, as this would wash away the soluble silicates.

The results, as a rule, were the average of 10 tests, the samples being immersed under water from the time of setting to the time of testing. The tables showed that, during the last six years, 1,369,210 bushels of Portland cement had been submitted to 11,587 tests, and that the cement was found to be of the average weight of 114·5 lbs. per bushel, and to possess an average tensile strength of 608·6 lbs. upon $2\frac{1}{2}$ square inches, being $51\frac{1}{2}$ and 21 per cent in excess of the two specified standards. It was also ascertained that, provided Portland cement kept free from moisture, it did not, like Roman cement, lose its strength by being kept in casks or sacks, but rather improved by age —a great advantage in the case of cement which had to be exported. Experiments, conducted over periods varying from one week to twelve months, with Portland cement weighing 112 lbs. to the imperial bushel,

gauged neat, and mixed with varying proportions of different kinds of sand, showed that neat cement was stronger than any admixture of it with sand; that mixed with an equal quantity of sand, (as had been the case throughout the Southern Main Drainage Works,) the cement might be said to be, at the end of a year, approximately three-fourths of the strength of neat cement; that with two, three, four, and five parts of sand to one of cement, the strength was respectively one-half, one-third, one-fourth, and about one-sixth that of neat cement. Other experiments show that at the end of twelve months, neat cement kept under water in a quiescent state was about one-third stronger than that which was out of water, both indoors and exposed out of doors to the action of the weather; that blocks of brickwork or concrete, made with Portland cement, if kept under water until required for use, would be much stronger than if allowed to remain dry; and that sea-water was as good for mixing with Portland cement as fresh water. Bricks of neat Portland cement, after being made three, six, and nine months, withstood a crushing force of sixty-five, ninety-two, and one hundred and two tons respectively, or equal to the best quality of Staffordshire blue bricks; and bricks of cement mixed with four and five parts of sand, bore a pressure equal to the best picked stock bricks; while Portland stone of similar size bore on its bed a crushing weight of 47 tons, and against its bed somewhat less, and Bramley Fall stone sustained on its bed 93⅓ tons, and against its bed 54⅔ tons. Portland cement concrete, made in the proportions of one of cement to six or eight of ballast, had been extensively used for the foundations of the river wall and the piers of the reservoirs at Crossness, as well as for the foundations generally both there and at Deptford, with the most perfect success. It was thought that it might be still more advantageously used as a substitute for brickwork or masonry, wherever skilled labor, stone, or bricks were scarce, and foundations had to be made with the least expenditure of time and money. Whenever concrete was used under water, care must be taken that the water was still, as a current, whether natural or caused by pumping, would carry away the cement and leave only clean ballast. Roman cement, though about two-thirds of the cost of Portland, was only about one-third its strength, and was, therefore, double the cost when measured by strength. It was besides very ill-adapted for being mixed with sand.

In conclusion, the author, whilst recommending Portland cement as the best article of the kind that could be used by the engineer or architect, warned every one who was not prepared to take the trouble, or incur the trifling expense of testing, not to use it, as, if manufactured with improper proportions of its constituents, chalk and clay, or improperly burnt, it might do more mischief than the poorest lime. Further experiments were desirable, on the strength of adhesion between bricks and cement, under varying circumstances; on the limit to the increase of strength with age; on the relative strength of concrete made with various proportions of cement and ballast; and on the use of cement in very hot climates, where probably extra care would be required in preserving the cement from damp, and keeping

it cool until the process of setting had been completed. On these and other important points, the auther trusted that all who had the opportunity would record their observations and present them to the Institution.

Proc. Inst. Civ. Eng., Dec. 12, 1865.

On the Adhesion of Locomotive Engines and Certain Expedients for Increasing or Supplementing that Function. By VAUGHAN PENDRED, C. E.

From the London Mechanics' Magazine, November, 1865.

(Concluded from page 91.)

Returning to the inside cylinders, we find that the piston rods are provided with cross-heads running in guides, although these last are hardly required, each piston driving two connecting rods. The piston rod of the leading cylinder is exactly over the mid-rail, and, of course, opposite to that of the after cylinders. Thus, neither of the cylinders is in line with the shafts they have to drive. But the two connecting rods from the forward cylinders proceed right and left to the two horizontal cranks on the forward vertical shafts and put them in motion precisely on the well-known system used by Cartwright, in Watt's time. The connecting rods from the after cylinder, however, do not take the crank pins of the actual trailing wheels, but instead they are forked and jointed on to the side coupling rods. The result is rather a singular motion, not very easy, perhaps, to trace out through all its stages and speeds, but giving in effect a result equivalent to that which would be produced if the cylinders worked on cranks at right angles to each other, and thus dead points are eliminated. Each of the vertical shafts is supported in two boxes, and these boxes are made to approach each other in order to regulate the amount of grip on the rails in the following manner: Across the engine, between the leading and trailing vertical shafts, runs an endless screw carrying outside the frame a worm wheel, into which a vertical screw gears. By causing the screw to revolve by means of a hand wheel, the transverse screw can also be put in motion. The brasses of the vertical axles are carried in cast iron boxes provided with grooves, which slide on suitable ribs placed across the engine. Exactly over the mid-rail are located two horizontal worm wheels, gearing with the transverse screw before mentioned. These wheels turn on axles fixed in the frame. To each is keyed a pair of eccentrics or cams projecting in opposite directions. These rotate within a pair of boxes, one for each eccentric, and these boxes are connected by rods with the lower boxes of the vertical wheels, strong helical springs being interposed in such way as to produce an elastic strain on the grip wheels. In order to make the wheels compress the rail, the transverse screw is caused to revolve, thus putting the large worm wheels in motion, and with them the eccentrics, which, in time, cause the low boxes to approach each other across the engine in pairs, and this motion is communicated

to the four upper boxes through the medium of four vertical rock shafts and links. All this is very complex, it must be admitted, and has been greatly improved upon since; but we shall do well to bear in mind that this engine accomplished all it was designed for, which was to take 16 tons up inclines of 1 in 12 or 13 at speeds of 7½ miles per hour or thereabouts on straight roads. The engine being completed was almost immediately afterwards tested at Whalley Bridge, on the Cromford and High Peak Railway, on a short piece of line expressly laid down for its gauge—3 feet 8 inches. The first trial took place on the 5th of January, 1864. There were two inclines on the line—one 200 yards long, with a gradient of 1 in 13; the other 550 yards long, on a grade of 1 in 12, with curves of about two chains or 132 feet radius. The engine easily surmounted these, with four wagons containing 26 tons of ballast—a performance which was at that time unique, considering the weight of the machine. In order to realize its exact character it may be remarked that these inclines are half as steep again as Holborn Hill at its steepest part.

Shortly after this engine had been finished, Mr. Alexander was instructed to prepare designs for a second, which differs in many important particulars from the first one. All the arrangements are much simplified; the boiler power is increased, and the results obtained have been much more satisfactory. All the experience gained in the construction of the first has been made use of, and, although the machine is not yet quite what it should be, it is at least comparatively perfect, and has proved itself safe and efficient. Built partly of steel, its net weight is 33 tons, and loaded 16 tons 17 cwt., inclusive of the extra machinery of the horizontal wheels, weighing 2 tons 13 cwt. The boiler is 8 feet 4 inches long, and 3 feet 2 inches diameter, and contains 158 tubes 1½ inch external diameter. The total heating surface amounts to 600 superficial feet, that of the grate being 10 feet. There are only two outside cylinders, 15 inches diameter, and 16 inches stroke, which work both the bearing and gripping wheels as follows: Across the forward end of the framing, in advance of the smoke-box, is placed a species of box girder, carrying at the middle of its length two bearings. Bolted to the side frames are two cast iron boxes bored out to receive each a rock shaft, the inner ends of which are carried by the bearings in the box girder. The outer arms of these rock shafts are coupled to plungers or rods working in guides, which are coupled to the outside wheels by ordinary forked connecting rods. Each piston has, so to speak, two rods, one proceeding through the forward end of the cylinder, the other through the back. The forward rod carries a cross-head working in guides, the cross-head being fitted with a pin taking into a box working in a slot in the second arm of the rock shaft. This is rather a roundabout way of driving the bearing wheels, but it works very fairly, and is susceptible of improvement in the matter of proportion more than anything else. Thus the crank pins are needlessly long, and the outer rocker arm too heavy. The inner wheels are united as before by coupling rods, the arrangements being much the same as those in the first engine. The inner

piston rods drive the furthest crank by means of ordinary connecting rods, working horizontally, of course. It will be seen, however, that so far no connexion whatever exists between the pair of horizontal wheels at the right hand side of the rail and those of the left. It was at first thought that no difficulty would be experienced in getting over the dead points, the engine once in motion. This was not the case, and gearing is used to couple the two systems. Instead, too, of the excessively complex compressing gear used in the first engine, a single right and left handed transverse screw, taking into deep bosses formed on longitudinal bars is employed. These bars rest on helical springs interposed between them and the two sliding frames carrying the bearings of the gripping wheels. The engine has been built by Mr. Cross, of St. Helens, who deserves much praise for the skill and care displayed in the construction, and I may add the design of this engine.

The next system claiming our attention is the "auxiliary steam tender" of Mr. Sturrock, engineer of the Great Northern Railway. It consists simply in the application of a pair of cylinders to the ordinary tender, which are supplied with steam from the boiler of the engine through a copper pipe, bent to easy curves, and, therefore, sufficiently elastic to permit of a flexible connexion between tender and engine. The scheme is not strictly novel, steam tenders having been used to work the coal traffic between Rive de Gier and St. Etienne from 1845 up to 1853. These engines were built by Verpilleur for a 40 lb. rail, and being found too light for their work, cylinders were added to the tenders, and, with this addition, they conducted the traffic on an incline of 1 in 60 with considerable success. Verpilleur's arrangement was clumsy as compared with Mr. Sturrock's, the steam pipe to the tender being led overhead across the footplate, while stuffing boxes were employed to compensate for its rigidity. Forty-six steam tenders are now at work on the Great Northern, but they are not yet fully employed, as certain engines to which they are intended to be fitted have not yet been delivered to the company. The waste steam from the tender cylinder is led through a few tubes placed within the tank, in order to raise the temperature in the feed-water, by which a considerable saving in fuel is effected. The coal traffic of the Great Northern is worked at the high average speed of twenty miles per hour, including stops; and as the line abounds in inclines of 1 in 200, several of them three and four, and one as much as eight miles long, while the weight of the train averages 280 tons, it is evident that a good deal of power is necessary. The steam tender engines have 16 inch cylinders, 24 inch stroke, and six coupled wheels 5 feet in diameter. It was found in practice that these engines made more steam than they had adhesion to work up in winter though not in summer. The auxiliary tenders have cylinders 12 inches diameter, 15 inches stroke, and six wheels, all coupled, 4 feet 6 inches diameter. They weigh full 29 tons. After they had been in use a short time it was found that the boilers in their normal form did not make sufficient steam for the additional adhesion. The fire boxes were therefore removed, and re-

placed by others of larger size, the inclined grate being carried above the trailing axle. The grate surface is thereby increased from 17½ feet to 26½ feet, the weight of the engine being increased by 10 cwt. Engines thus altered take, I understand, gross loads of 450 tons, their normal load being increased from 30 wagons, containing 7 tons of 21 cwt. to the ton in each, to 45 wagons, or 315 tons net, up inclines of 1 in 178. The tenders are in use but a couple of years, during which time they have run 1,011,963 miles up to the 26th of last August, 430,000 of these having been run during the six months ending 30th of June. The system has, I believe, proved thoroughly successful, the power of the engines being increased by about 50 per cent. in return for an expenditure of £450 to £500. The tenders weigh empty about 18 tons, or half as much as the engine, so that the consumption of coal and water while running does not practically affect the adhesion. The entire idea thus embodied will be seen to correspond in many respects with those of Flachat and other continental engineers. The details have been worked out with so much care that we must accord Mr. Sturrock a fair proportion of the credit due to an original inventor.

I have said that I would refer to the different modern systems of supplementing or increasing adhesion in the order of their importance. I must add that I measure this importance, not by the skill or talent of the inventor or by the originality of his views, but by the degree in which these have been reduced to practice, and the specific object they are intended to subserve. It is possible that the system to which I now beg leave to call your attention is more strictly novel, if not remarkable, than either of those we have just considered. Mr. W. B. Adams, well known for his inventions in connexion with railways, has produced an engine for sharp curves, which also embodies a means of supplementing adhesion well worth attention. The idea of coupling chairs by the aid of friction wheels has been broached before, but never in the form which Mr. Adams has given it. According to this arrangement the whole weight of the engine is supported on all the wheels as driving power, and that while permitting the engine to roll round curves of as small a radius as a chain and a half, with a total wheel base of 20 feet to 24 feet. This is effected by applying friction wheels between the two pairs of central and end wheels, their axles passing between the boiler and frame. The two pairs of middle wheels are applied in the ordinary way with axle guards, one pair having a crank axle attached to a pair of inside cylinders, and connected by side rods to the other pair of wheels, both pairs having inside bearings. The end wheels have outside bearings giving a wide spring base which steadies the engine. The axle boxes are of the ordinary kind, and they have no horn plates which would be in the way. The bearing springs swivel on a centre pivot, and support their load from long rods attached to balls and sockets, connected with scroll irons or brackets on the frame. Thus free movement is given to the leading and bearing wheels and axles, both forward, backward, laterally, and diagonally. But it is essential to control this movement, so that the axles may only move in a true radius with the curves of the rails.

To accomplish this the whole axle between each pair of wheels is fitted with a curved bed struck from a centre equal to one-fourth the total wheel base. This curved bed works on a second frame, corresponding to it in form, fixed to the inside frame of the engine. Thus these end axles with their wheels work in the curve, impelled by their flanges against the rails; and this curved frame takes all the thrust caused by the pressure of the friction wheels between the lower wheels. This pressure can be increased or diminished at the pleasure of the driver by levers acting on volute springs, or the wheels may be lifted altogether from contact. The three pairs of wheels at each end thus act simultaneously, the driving power at the crank axle impelling the whole. On a straight line the gravitating action of the spring shackles keeps them vertical; on the curve the pressure of the flanges places the end wheels at an angle, so that in the inside of the curve the end wheels approach the centre and on the outside go further apart, their axle reclining from the horizontal position to one side or the other. The friction wheels work independently on their axle, and the tires are provided with flanges to interlock them with the centre and leading or trailing wheels. If the connected wheels were rigid on their peripheries there might be a tendency to jump and slip, as with all rigid wheels, and so lose their hold. To insure against this defect the wheels are all provided with springs underneath their tires, which allow them to fit each other and ensure adhesion. The engine is fitted with a pair of steam cylinders on each side of the frame, the piston being pressed down by spiral springs inside to keep the brake out of use, and when the steam is admitted the springs are overpowered and the brakes are lifted into contact with the wheels. In order to increase the adhesion for very steep gradients the flanges of the wheels are made V form, and enter a corresponding rail, traveling on the ordinary rails when not on steep inclines.

This paper has already extended to such a length that I can do little more than glance at the last section of my subject—the application of magnetism as a means of increasing adhesion. It happens, however, that the idea, although often tested on a large scale, has resulted in nothing; nor is it likely that it will ever be resorted to in practice. It may, in short, be regarded more in the light of an ingenious abstract mechanical device than in that of a practical expedient likely to serve a really useful purpose. I believe the idea is very old, M. Weber being the first to suggest it, while Liebig mentions it in many of his earlier letters; but the first patent taken out, in this country at least, bears date 1850 only. It was secured by M. Amberger, to whom the credit of the invention, such as it is, is due. Its history is very simple. In or about the year 1850, the Austrian Government appointed a commission to inquire into the best means of providing sufficient adhesion to work the Semmering incline, with grades averaging 1 in 47. The commissioners applied, among others, to M. Amberger, an engineer of some eminence, who suggested the plan of magnetizing the driving wheels by electricity. Amberger's suggestion was adopted by the commission, and funds were placed at his disposal

to make experiments. He called in the assistance of an electrician, M. Nicklés, and after some models had been constructed, and the fact demonstrated that it was possible to increase the co-efficient of adhesion, they proceeded to test the scheme on a large scale. For this purpose an engine on the Lyons Railway was placed at their disposal. The engine weighed 30 tons, supported on six wheels, of which four were coupled. It was found, however, that this engine had more adhesion, thanks to the coupling, than it had cylinder capacity to work up, and therefore the coupling rods had to be removed. The magnetizing apparatus consisted simply of a coil of insulated copper wire wound on a species of brass bobbin surrounding the lower part of the wheel. The battery consisted of 64 Bunsen elements, and the length of the wire was about 1700 yards. The force of attraction equaled, when the train was at rest, 639 kilogrammes, or 12 cwt. 2 qrs. 11 lbs. for each wheel; and so far it is obvious that there was a decided gain. But a very singular phenomenon, and one altogether unanticipated, supervened the moment the train was put in motion, which was simply that as soon as the wheel began to revolve the force of attraction diminished. Thus, at thirty revolutions per minute the force of attraction fell off from 12·5 cwt. to 5 cwt.; while at sixty revolutions it fell to but 3 cwt. 27 lbs. Without entering deeply into the theory of the electro-magnet, this may be easily accounted for in the following way: The top of the wheel is converted into one pole of the magnet—say the north—the bottom of the wheel into the south pole; but the south pole is more strongly magnetic than the north, because it is next to the coil. As the wheels revolve, however, the south pole continually becomes the north, and *vice versa*. But it is well known that electro-magnets retain small charges of magnetism after the current is broken, while any change of polarity requires a little time to be fully accomplished. When the wheel or wheels revolve rapidly this time is not allowed, and the result is a species of confusion in the polarities, and a consequent weakening of the magnet. Nicklés then produced another system, in which the coil is disposed in the same plane as the wheel, with which he obtained better results, the magnetism not being affected by the revolution; but the arrangement is inapplicable to engines of the ordinary construction, with high drivers, and must interfere so considerably with the entire design of the engine in any case, that I cannot think it likely that it will ever find its way into practice. Indeed, the best results Nicklés obtained only gave an increase of adhesion equal to 8·5 per cent.—a very poor return indeed for the trouble and expense incurred in the construction and manufacture of a complex electrical apparatus. The idea is still being worked out, I believe, both here and in America. Sir Charles Fox, for example, has recently tried many experiments on the Great Eastern Railway, which have ended in nothing, except in proving that a few handsfull of sand enabled the engine to surmount inclines with a given load which it was unable to cope with even when the wheels were powerfully magnetized.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

The Lenoir Gas Engine. By FRED. J. SLADE.

Having had considerable opportunities for observing the practical working of this machine, the writer has thought some of the phenomena of its operation of sufficient interest to be made public. The principle of its action is as follows: The piston moving at the beginning of its stroke by the momentum previously imparted to the fly-wheel, draws into the cylinder, through a suitable slide valve, a mixture of common illuminating gas and air. When the piston has moved through a little less than half the stroke the valve closes, and an electric spark is introduced into the cylinder and ignites the gases. The expansion caused by the heat of combustion drives the piston during the remainder of the stroke.

The composition of coal gas is not the same in all cases, but varies with the kind of coal used in its manufacture, and the extent to which the distillation is carried. A constitution probably not far from the average in our cities would be expressed by

Olefiant gas, ...	7
Light carburetted hydrogen, ...	56
Hydrogen, ...	21
Carbonic oxide, ...	11
Nitrogen, ...	5
	100

Now, in combustion 1 cubic foot of olefiant gas unites with 3 cubic feet of oxygen and gives 2 cubic feet of carbonic acid and 2 of vapor of water. One cubic foot of light carburetted hydrogen unites with 2 cubic feet of oxygen and gives 1 cubic foot of carbonic acid and 2 of vapor of water. One cubic foot of hydrogen unites with one-half a cubic foot of oxygen and gives 1 cubic foot of vapor of water. One cubic foot of carbonic oxide unites with one-half a cubic foot of oxygen and gives one cubic foot of carbonic acid.

The result of the combustion of 100 cubic feet of coal gas, therefore, will be represented as follows:

			Oxygen.		Carbonic Acid.	Vapor of Water.
Olefiant gas, ...	7	+	21	yields	14	14
Light carburetted hydrogen,	56	+	112	"	56	112
Hydrogen, ...	21	+	10½	"		21
Carbonic oxide, ...	11	+	5½	"	11	
Nitrogen, ...	5			"	Nitrogen 5	
	100		149		86	147
Nitro. associated with oxygen in air,			560		560	

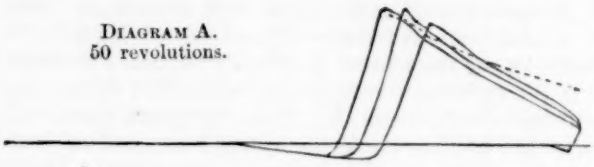
Original gases, ... 809 yield products of combustion, 793.

We see from this that for the perfect combustion of gas of ordinary quality we must supply seven volumes of air for each volume of gas, and that for gases containing a greater proportion of hydro-carbons

a greater quantity of air will be required, and, at the same time, the bulk of the products of combustion will be greater.

By applying a Richard's indicator of unusually delicate workmanship the writer obtained from an engine of $8\frac{3}{8}$ inches diameter of cylinder, and $16\frac{1}{4}$ ins. stroke, diagrams of which the accompanying is a fair specimen.

DIAGRAM A.
50 revolutions.



In this case as the explosion did not occur immediately on the closing of the valve, the tension of the gases falls to 11 lbs. per square inch, (above a vacuum.) After combustion it rises to 48 lbs. The temperature necessary to produce this pressure is found by the formula,

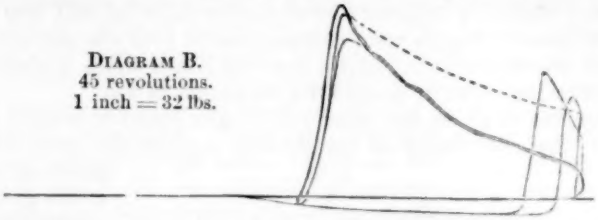
$$t_2 = \frac{p_2\Big(1 + k\,(t_1 - 32°)\Big) - p_1}{p_1 k} + 32°,$$

in which t_1 = temperature of the gases before combustion, taken at 200° on account of the warmth of the cylinder.

p_2 is 48 augmented in the proportion $\frac{8}{7}\frac{9}{3}$ and the mean co-efficient of expansion k of the gases under constant volume is ·00204. This gives us as the temperature of the gases at the moment of combustion 2474°. The dotted line represents the theoretical curve of expansion, taking into account the loss of heat and consequent fall of pressure due to the work done, (which is the proper theoretical curve for an indicator diagram.) The temperature at the end of the stroke indicated by this line would be 2156°. The actual final temperature shown by the diagram, supposing there to be no leakage, is 1438°, and the difference, 718°, is the quantity of heat absorbed by the water jacket with which the cylinder is surrounded. It will be observed from this card, that the explosion takes place so late in the stroke that there is a considerable available pressure in the cylinder at the end of the stroke, which, of course, is not utilized. To prevent this waste, the manufacturer of these engines in this country, Mr. Miers Coryell, sets the admission valve so as to close earlier; and this has the further advantage, that at the middle of the stroke a given quantity of work is performed in less time than at the ends, and consequently there is less loss of heat.

The diagrams give information which may be of interest to some as to the time required for the explosion of such a mixture of gases. In this case it appears to be about $\frac{1}{27}$ of a second.

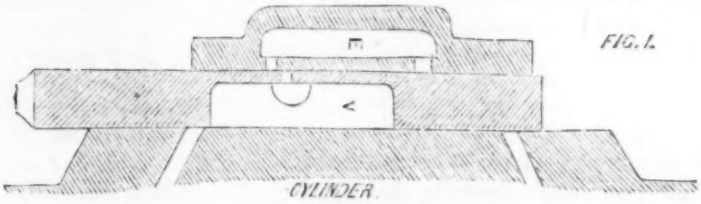
Diagram B was obtained on one occasion when the electrical points in the cylinder were wet, and owing to the uncertain passage of the spark the explosions were very irregular. It is introduced here to show the difference between explosions occurring at the middle of the



stroke and those nearer the ends. It will be observed that the pressure attained in the later explosions rises somewhat higher than the true expansion curve drawn from the point attained by explosion near the middle of the stroke, (which, as for this purpose, there is no work to be taken into consideration, would stand at the end of the stroke 4·2 lbs. higher than that shown.)

This is probably due to the greater heat acquired by the gases before explosion. It will also be noticed that the time of acquiring the maximum pressure is considerably greater in the later explosions, being $\frac{1}{30}$ of a second in the earlier and $\frac{1}{20}$ or more in the later.

Lastly, the great loss of pressure by cooling is strikingly shown—in equal times the lines fall below the height due to expansion alone by an amount proportionate to the pressure that the gases would have



at 32°. In the early explosions in this diagram, the pressure rises from 13 lbs. before explosion to 60 lbs. after, corresponding to a temperature of 3090°. The dotted line represents, as before, the true expansion curve, including the loss of 420° of heat and resulting diminutions of pressure due to the work done.

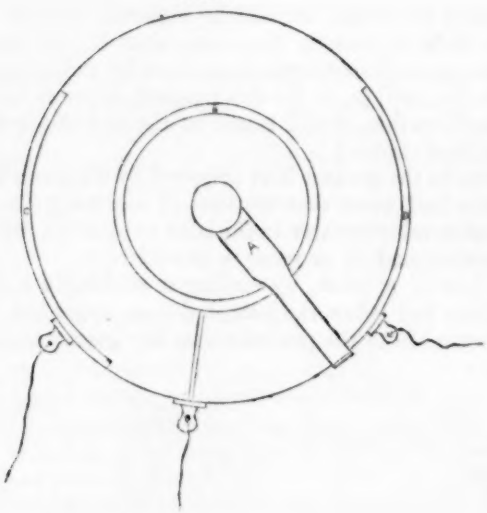
The construction of these engines is simple, differing in but few particulars from an ordinary horizontal steam engine. The cylinder and heads, as has been intimated, are cast hollow and kept cool by a current of water passing through them. The gas and air are admitted by a slide valve shown in Fig. 1. The gas pipe is connected to the chamber E bolted to the cylinder, and between which and the cylinder the slide valve V moves. The gas passes through the small port shown in the back of the valve into the semicircular channel which covers it, and through this up and out of the valve into the atmosphere. It

is then drawn down again by the suction of the piston through a number of small holes into the cup of the valve, and thence into the cylinder. This insures its thorough mixture with the air, while, at the same time, it prevents the possibility of explosion, since there is nowhere any explosive mixture except in the cylinder and cup of the valve, the latter being in open communication with the atmosphere.

An air chamber with openings, regulated by a slide, is placed over the holes in the valve to control the admission of air.

A separate valve on the other side of the cylinder is used for the exhaust. As constructed in the French engines this part is a weak point on account of the great heat to which it is subjected from the escaping gases. In the American engines, a small current of water passes through this valve and entirely removes this difficulty.

FIG. 2.



The spark for igniting the gas is supplied by a Bunsen's battery of one or two cells, and a Ruhmkorff coil giving from 100 to 150 sparks per second. It is distributed to each end of the cylinder by an arrangement shown in Fig. 2. An arm A insulated on the end of the shaft conducts the spark from the insulated ring B in connexion with the coil alternately to the segments C and D connected by wires to the respective ends of the cylinder. This arm is set so as to touch the proper segment just as the admission valve closes.

To most persons it would probably appear that the great heat generated in the cylinder would be destructive of the surfaces. The writer, however, examined an engine that had been running regularly for a month, using in that time less than a quart of oil, and was surprised to find that the bore of the cylinder and the piston rod, though dirty from deposits of impurities, were not even scratched.

The explosion of the gas is unattended by any noise unless the connexions are slack. The only size as yet constructed in this country is $4\frac{5}{8}$ inches diameter of cylinder by $8\frac{3}{4}$ inches stroke, though engines of larger dimensions are in process of construction. A friction dynamometer applied to one of these gave the following result

Length of lever, ...	4 feet.
Weight applied, ...	7 pounds.
Revolutions per minute, ...	185

16,280 foot-pounds per minute = ½ horse power.

In France there are engines of 3 horse power and upwards, but with the exorbitant prices of gas in this country, 1 or 2 horse power is probably as high a power as could economically be obtained from this motor. These engines have the advantage that the expense ceases immediately with the work, which is an especial recommendation where the work is intermittent. They can be started and stopped instantly by merely turning the gas cock. They are absolutely free from danger and do not require the attention of an engineer; hence for small powers they are cheaper than steam. On account of their safety, they are admissable in situations where steam would not be.

Dry Dock Iron Works, New York.

Retardation of Electric Waves in Submarine Telegraphic Lines.

From the London Mechanics' Magazine, December, 1865.

In a paper on electric conduction, from the pen of Mr. John James Waterson, which appears in the new number of the "*Philosophical Magazine*," that gentleman reiterates the opinion, which he expressed in a paper on the same subject some few months ago, that voltaic electricity is conveyed solely by the *surface* of the conductor, and not, as is ordinarily taught, by the entire thickness thereof, and proposes a "crucial experiment" for the purpose of ascertaining whether or not this opinion is in accordance with the fact. The proposed experiment would consist in measuring, by means of M. E. Becquerel's apparatus, the conducting power for voltaic electricity of an iron wire plated with copper, and that of a copper wire coated with tin. Mr. Waterson believes that the copper-coated iron wire would be found to conduct as well as a copper wire of the same thickness, and that the tinned copper wire would be found to conduct no better than a tin wire of the same dimensions, and that it would thus be established that voltaic electric conduction is a purely surface phenomenon. Should this prove to be the case, Mr. Waterson is of opinion that it would be found practicable to avoid the retarding effect of induction in submarine cables. "The mere covering of gutta percha upon a wire," he remarks, "does not cause retardation. The presence of a conducting medium on the outside of covered wire is also necessary. Hitherto experiments seemed to have been confined to iron and water as the outside conductors. So far as I know, the effect of copper as outside conductor has not yet been tried. Iron has one-sixth or one-seventh the conducting power of copper; water only about a thousand millionth. Electric conduction as a whole depends on the freedom of motion allowed to the force as a whole. *The induced current should thus have the same freedom to move as the primary.* Practical considerations would probably require that the outside copper conductor should be insulated; so that, to make the trial effectively, it would be necessary to connect the outside coating (of woven thin copper wire) with

one pole of the battery, while the other pole led to the central wire. At the signal end, of course, there must be a similar arrangement, and this would give to the induced current the same propelling force as the primary, and utilize the half of the power of the battery that is now lost by putting to earth." Further on he insists that it is essential that the outside and the inside conductor should be of the same metal, and that his proposed arrangement "would exclude earth-currents; and if the signal house, as well as the shore end of the cable, be iron covered, it is difficult to see how atmospheric electricity could intrude upon the signals." It certainly seems desirable that this gentleman's theories should be practically tested.

On the Hydraulic Properties of Magnesian Limes. By Mr. F. Crace Calvert.

M. H. Ste. Claire-Deville read to the Academy the following note by Mr. Calvert:

"In September, 1862, I was employed by the directors of the Dinorben Company, which is working the magnesian limestones near Amluch, in the island of Anglesea, (N. Wales,) to ascertain whether certain beds of magnesian limestones, existing at Port Cynfor and at Hellsmouth Bay, could be practically used. After some preliminary trials, I satisfied myself that certain beds could be advantageously used; some as hydraulic cement, others for hydraulic lime, others for stucco.

"In order to learn the cause of their different hydraulic properties, I analyzed several, with the following results:

	Hydraulic Cement. Carigeract.	Hydraulic Lime. Port Cynfor.	Stucco. Hellsmouth.
Carbonate of Magnesia, . .	61·5	55·23	15·86
" Lime, . .	21·41	33 99	72·23
" Iron, . .	8·76	3·85	3·21
Silica, ...	5·58	5·58	2 70
Alumina, ...	2·07	2·27	
Organic matters and water, .	1·10	3·40	6·

"These facts show that the degree of hydraulic property of these magnesian limestones is in proportion to their content of carbonate of magnesia.

"I compared with the greatest care the degree of hydraulic property of the products of these minerals with those of the best cements and hydraulic limes in England, that is, with the best quality of Portland cement and the lime obtained from the blue lias limestone, and I obtained results which were completely identical, although these stones are in composition very different from the former.

"Like M. Deville, I observed that it was necessary to take the greatest care in the calcination. The temperature must be gradually raised to a red heat, and kept there until all the carbonic acid is driven out;

for if they are exposed to a higher temperature, a compound is formed of the lime and magnesia, or a change in their molecular condition, which renders them unfit for use. I also remarked, that after calcination they ought to be reduced to a very fine powder. The more finely they are powdered the more tenacious and homogenous they become under water."

In presenting this note to the Academy, M. H. Ste. Claire-Deville remarked, that it was evident at first sight that the hydraulic properties of the cement analyzed by M. Calvert were almost entirely due to the exceptional quantity of magnesia which that dolomite contained. Five per cent. of silica would not be sufficient to give such energetic hydraulic properties to a pure limestone. But it must be remarked, that this small quantity of silica was of essential service in these circumstances. It prevents the lime from becoming injurious in case a too high heat of calcining should introduce it into the cement; for, upon recalling my former communication, and paying attention to the last lines of Mr. Calvert's note, it will be remarked that in a magnesian cement the lime must remain as a carbonate so as not to be injurious. If we calculate according to the excellent data of MM. Rivot and Chatonnay, the quantity of lime which the silica and alumina can transform into a hydraulic material, and add to the alumina the oxide of iron produced by the calcination of the carbonate contained in the Carigcract stone, taking account also of the observations of M. Malagruti, we see that this hydraulic material must be composed of—

Silica,	5·6
Alumina,	2·1
Sesquioxide of iron,	6·
Lime,	6·7

So that of the 12 per cent of lime which an overheated calcination of this limestone might give, but 5·3 remain caustic, the influence of which on the setting of the magnesia is altogether insensible.

So that the good qualities of the Carigcract cement, so well established by Mr. Calvert, are due: 1st. To 29·1 per cent. of caustic magnesia, which can solidify a considerable quantity of inert material, and 22 to 20 per cent. of the hydraulic matter of ordinary cements, which would be absolutely inefficient in a limestone to make cement, but which add their action to that of the magnesia.

Proc. Acad. Sciences of Paris.

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*India Rubber considered in reference to its Applicability as an Insulator for Telegraphic Conductors.** By WILLIAM HOOPER.

From the London Civil Engineer and Architects Journal, December, 1865.

The difficulties which have preceded the successful issue of india rubber insulation are precisely the same which were encountered for many years after the introduction of this substance as a branch of manufacture. Native or raw india rubber, when in good condition,

*Read before the British Association.

may be kept for years without sustaining any deterioration, but in certain stages of its manufacture it becomes susceptible of decay, which is accelerated by exposure to air and light. The decay of india rubber is now well known to be the result of oxidation, and is characterized by a gradual tendency to fluidity; its first stage of decay is recognised by a diminution of its elasticity, and by its becoming glutinous or sticky, and finally being reduced to a tarry-looking fluid, which state it always preserves.

The ultimate composition of india rubber is represented by the formula $C_8 H_7$. The analysis of Dr. Miller accords, with tolerable exactness, with this formula. He found in 100 parts 85·82 carbon and 11·11 hydrogen. The sample which he analysed, however, contained 3·07 oxygen, and evidently could not have been pure caoutchouc. Neglecting the oxygen, the composition of pure caoutchouc, as reduced from its empirical formula ($C_8 H_7$), is 84·56 carbon and 12·33 hydrogen, the difference in which from the results by Dr. Miller's analysis is practically nothing, and confirms the accuracy of the original analysis.

India rubber in its manufactured state contains more or less of its oxidised product, which produces the color recognised in this substance, pure caoutchouc being colorless. The word caoutchouc should properly be applied to that pure principle of carbon and hydrogen which forms the greater part of manufactured india rubber.

The process by which india rubber is rendered suitable for the purposes of insulation, consists of an operation which involves its partial oxidation, and unless this oxidation is arrested, the india rubber becomes useless as a permanent insulator. India rubber when thoroughly washed and dried is masticated, by which means it becomes highly colored, and is afterwards found to contain a variable amount of its oxidised product. By mastication, the india rubber is converted into solid masses or blocks, which are cut up into slabs or sheets; the sheets are again cut into tapes, which is the only form for applying it to telegraphic conductors. The tapes being put on the wires, another operation is required to reduce them into a perfectly uniform and solid covering. This has been usually effected either by the use of solvents or the direct application of heat, both of which plans are seriously objectionable. By the application of solvents, the india rubber becomes more susceptible of oxidation, whilst the direct application of heat induces a molecular change more favorable to its oxidising. Wires insulated by either of these means, indicate a very high state of insulation when first made, but as the india rubber decays the insulation is reduced, and ultimately destroyed.

About two years ago five lengths of india rubber insulated wires were supplied to the government for submersion in the Persian Gulf, which, with the exception of one, have failed almost entirely. I was favored with a report from government a few weeks ago, made by Mr. F. C. Webb, from which it appears that the length remaining perfect is, at the temperature of 75° Fahr., three times better than the gutta percha insulated wires which form the core of the Persian Gulf cable.

Mr. Webb stated in his report that he did not know who were the respective manufacturers of these several lengths, but he brought home a piece cut from each length for identification. On my calling upon him, he placed several pieces before me, and I had no difficulty in recognising my manufacture. Mr. Webb at once said that it was off the length which he had reported to the government as being the only one that remained perfect. It will be seen from these numbers that it is the highest degree of insulation yet practically attained. A length of 1610 yards, tested under a pressure of 6000 lbs. per square inch, and the same length, tested again under a pressure of 4480 lbs. per square inch, maintained for nearly eighty hours, showed an increase in its insulation resistance; and on removal of the pressure it was not found to have diminished, as has been stated to be the case with some specimens of india rubber insulated wire. The length under this test contained two joints. The high results obtained from joints in my insulated wires have entirely removed all apprehensions on this important point, and there is no practical limit to the age of the material in which joints can be safely and reliably made. Five miles of my insulated wire, containing in each case eight and twelve joints, were uninterruptedly maintained at the temperature of 75° and 95° Fahr., respectively, for 240 hours, and on being reduced to the initial temperature were found to have suffered no permanent change.

The facilities offered by my process for producing insulated wires of nearly identical degrees of insulation, and for reducing the most minute fault, enable me to bring forward this system as one by which absolute freedom from defects can be insured. This is a point intimately connected with the success of submarine telegraph cables; for it frequently has happened that minute faults have, on submergence, enlarged into sources of serious annoyance. The central position of the conductor is unaltered by any elevation of temperature, and as it maintains a high degree of insulation at 150° Fahr., or even higher temperatures, it is peculiarly applicable for tropical seas. In its resistance to mechanical injury it far surpasses all other materials which have been tried for insulating telegraphic wires. The low inductive capacity of india rubber renders it especially suitable for telegraphic cables, and by my process the low induction of india rubber is maintained.

Sir Charles Bright, Mr. Latimer Clark, and Professor William Thomson have favored me with the details of some very interesting investigations which they have gone through, on the qualities of my insulated wires, and, as Professor Thomson was not aware that Sir Charles Bright and Mr. Latimer Clark were giving their attention to the subject, it is highly satisfactory to find how nearly they agree in reference to the inductive capacity compared with gutta percha. Prof. William Thomson found the induction of my wire, as compared with that of gutta percha, to be as 100 to 135, while Sir Charles Bright and Mr. Latimer Clark found it as 100 to 136. Mr. Wildman Whitehouse examined a length of one of my higher insulated wires, which he found as 100 to 160. As the rate of signalling is governed by the

retardation arising from inductive charging, the transmission of messages will be inversely as these numbers; that is to say, that 135 to 160 messages could be sent through an Atlantic cable by using a conductor insulated with india rubber according to my process, whereas 100 only could be sent in an equal time by using a conductor insulated with gutta percha. This has a most important bearing in a financial point of view, since the cost of insulation by my method would not be greater, and in some of its forms considerably less, than that paid for insulation by gutta percha.

(Several lengths were shown to the sections, and also a diagram illustrating the effects of temperature as compared with gutta percha.) The mathematical properties of the curve were, for the temperatures determined on my core, similar to those obtained with gutta percha, but the differences in the insulation for increase of temperature were not so great as are observed to take place with gutta percha.

The following table gives the insulation resistance in milllions of B A units of my core and gutta percha, at different temperatures:

	0° Cent.	24° Cent.	38° Cent.
Gutta percha, (Persian Gulf core,) . . .	3205	170	45
Mr. Hooper's core, ...	71036	6328	2283

A length containing a joint that had been kept in a boiling solution of salt (220° Fahr.) for twenty hours, was placed in a vessel to be again heated to that temperature and tested, but the committee decided that it was unnecessary to test it, or any of the specimens and joints exhibited.

The specimens and joints had been made at different periods during the last four years, and were shown for the purpose of being examined, to see that they had not suffered any change. Amongst the specimens was a length of a half a mile with a joint cut from the five miles referred to above.

During the discussion which ensued,

Mr. Siemens, F. R. S., expressed his concurrence with Mr. Hooper's remarks on the value of india rubber insulation, as compared with that of gutta percha, except that india rubber improves in insulation under pressure. With that exception, he considered that Mr. Hooper had kept within rather than gone beyond their relative properties. Difficulties had hitherto been found in the application of india rubber as an insulator, and it would be interesting to the section to know how Mr. Hooper had overcome them.

Mr. Fleeming Jenkin, F. R. S., stated that he had for some years been acquainted with Mr. Hooper's method of insulation by india rubber, and he had never seen a length of his manufacture that indicated loss or decay. He considered the difference between the result of testing under pressure by Mr. Siemens and that by Mr. Hooper was caused by Mr. Hooper's process in consolidating the india rubber; his experience tended to confirm the statements made by Mr. Hooper. He thought it exceedingly desirable that Mr. Hooper's cable should be practically tested by being submerged and worked, as it was evident that for long lengths and tropical seas, it seemed to possess very valuable properties as compared with gutta percha.

Mr. Gassiot, F. R. S., said he thought the experiments in connection with the submergence of the two Atlantic cables had demonstrated that the two mechanical difficulties of the task could be overcome with a moderate degree of care and attention, and the most important consideration was that it had been demonstrated possible to lay a cable between Ireland and Newfoundland, but they must take care and not do as had been done in other cases, viz: lay down a cable which would only last two or three years. In this connection, Mr. Gassiot pointed out the importance of the cable produced by Mr. Hooper, although he questioned if the time had arrived for a final experiment in the laying down and working of an Atlantic cable. He thought the bearing of india rubber in its various qualities as an insulator ought to be satisfactorily and conclusively determined before the laying of another cable was attempted. If they went on from year to year unsuccessfully, they would absorb any amount of capital, and the citizens to whom they must go for material support would close their purses, whereas, if they only waited the result of the experiments being diligently prosecuted by electricians, they would be able to come forward with a scheme which would not only be a success, but practically with the best cable. There would then be no difficulty in raising capital, for there was no doubt that the Atlantic Telegraph would be laid, but before again embarking on the enterprise every experiment should be made. This was the only prudent and safe course to adopt. He understood the government had sent out, two or three years since, several lengths of insulated wire by different manufacturers to Kurrachee, including one by Mr. Hooper, to be practically tested by submersion in the Indian Seas, and a report had been lately furnished to the government stating that all of them, except the length supplied by Mr. Hooper, had failed. The report to government went on to state that Mr. Hooper's cable tested three times better than the Persian Gulf cable, which is insulated with gutta percha; the government had, in consequence, given Mr. Hooper an order for about fifty miles of his cable, to be supplid forthwith. He considered the Atlantic Company might well follow the example set by the government.

Electric Light for Light-houses.

It would seem that the substitution of the electric light in light-houses does not present so much advantage as had been anticipated. At a lecture delivered upon the subject by M. Leroux, it was stated that the electric light on Cape La Héve (near Havre) gave a light equal to 125 standard burners, (carcel 0·8 inches diameter, burning 617 grains of colza oil per hour,) and cost 3·84 cents per burner per hour. The oil lamp gave a light equal to 23 standard burners, and cost 1·52 cents per burner per hour. (Experiments made upon a smaller scale, but probably with more precision, at Paris, give as the ratio of the cost of equal lights by electricity and by oil $\frac{375}{100}$.) The useful effects do not appear to be in proportion to the expense. Thus when the standard

light was visible only at a distance of 2 kilometres, (1¼ mile,) the oil lamps in the Fresnel lantern showed the light, when fixed, at 3 miles, when revolving, at 3·7 miles. Under the same conditions the range of the electric light was 3·6 and 4·2 miles. The difference is not commensurate with the excess of expense. It is true that in case of foggy weather the intensity of the electric light may be with more facility increased, but this would lead to a very serious inconvenience of having a light of irregular intensity, and thus preventing mariners from judging correctly their distance from it.

Force of Insects.

Borelli, La Hire, Regnier and others have determined, with more or less care, the ratio between the weight of certain animals and their muscular force. According to Regnier, a man is capable of drawing 0·86 of his weight; a horse can draw only 0·67. (This is the weight lifted by the force of draught.) M. Felix Plateau has recently published a very valuable series of experiments upon the drawing, pushing, and flying forces of different insects, which we judge to possess interest and curiosity enough to justify us in publishing an abstract of them.

Drawing force.	Mean ratio of weight drawn to weight of body.	Drawing force.	Mean ratio of weight drawn to weight of body.
Carabus auratus, .	17·4	Anomala frischii, .	24·3
Nebria brevicouis, .	25·3	Oryctes nasicornis, .	4 7
Necrophorus vespillo,	15·1	Geotrupes stercorarius,	9·8
Silpha livida, . .	24·4	Onthophagus nuchicornis, . .	14·4
Ocypus morio, . .	17·0	Apis mellifica, . .	20·2
Quodius fulgidus, .	29·6	Cicindela Hybrida, .	12·1
Cetonia aurata, . .	15·0	Donacia nymphæa, .	42·7
Trichius fasciatus, .	41·3		

These numbers are almost regularly in the inverse ratio of the size of the insect.

PUSHING FORCE.

Oryctes nascicornis, ...	3·2
Geotrupes stercorarius, ...	16·19
Onthophagus nuchicornis, ...	79·6

FLYING FORCE.—Measured by the ratio of the weight with which the insect could fly, to the weight of its body.

Neuroptera, .	Aeschene grandis, . .	0·79
	Libellula vulgata, . .	1·01
	Lestes sponsa, . . .	0·71
	Agrion pupilla, . . .	0·74

Hymenoptera,	Bombus terrestris,	0·63
	Apis mellifica,	0·78
Diptera,	Eristalis tenax,	1·48
	Syrphus corollæ,	1·84
	Calliphora vomitoria,	0·93
	Musca domestica.	1·77

As these insects are all European, we are obliged to keep their scientific names, noting only that apis mellifica is evidently the honey bee, that libellula is a dragon-fly, probably not the same as ours, and that musca domestica is the European house-fly, whether the same as others we do not know, but hope that it is not a greater nuisance.

On Deaths by Lightning.

Extract of a note by M. Bondin, Academy of Sciences of Paris, November 27, 1865.

In the course of the year 1864 the number of persons in France who died from the immediate effect of lightning was 87, of whom 61 were males, 26 females. In 1863 the number was 103. In the period from 1835 to 1864 it was 2311 for the 86 old departments of France, and adding 120 (or 4 per year for each of the 3 new departments), we get for the present France, for a period of 30 years, a total of 2431 deaths by lightning. We believe that we have shown, by a great number of facts, that the number of persons wounded by lightning is at least four times that of those killed immediately, the only category reported by the government. Hence, it results that from 1835 to 1864 the total number of killed and wounded was 12,000, or a mean of 400 victims per year.

During this period the proportional number of persons killed varied exceedingly from one department to another. The ratio in *Lozere* was 31 times greater than that in *La Manche*. In the table which we present showing the distribution of the 87 deaths by lightning in 1864, the most striking result is the very unequal distribution between the two sexes, only 26 females for 61 males. From 1854 to 1864, inclusive, there were recorded 967 persons killed, of which 698 were males and 269 females, from which it would seem that only the small proportion of 28 per cent. of those killed by lightning are females. In England, the proportion is only 22 per cent. This comparative immunity cannot be attributed to greater exposure of men out of doors; for it exists even among children less than 15 years old, among whom the ratio of female deaths is only 16·6 per cent., and we may add that, in a great number of cases in which the lightning fell among groups of persons of both sexes, there was a decided immunity shown for the female sex.

Experiments and Observations on the Oxidation of Vegetable Oils.

By M. S. Cloez.

In a third memoir upon this subject, read to the Academy of Sciences of Paris, M. Cloez announces the following results of his experiments and observations :

1. That all the fat oils absorb oxygen from the air, and increase in weight by quantities which differ for different kinds of oil placed under the same circumstances, and for the same oil under different circumstances.

2. That the height of the temperature exercises a very marked influence on the rapidity of the oxidation.

3. That the intensity of the light also manifestly influences the phenomena.

4. That light transmitted by colored glasses checks more or less the resinification of the oils by the air. Starting from colorless glass as the term of comparison, the decrease of oxidation is in the following order: Colorless, blue, violet, red, green, yellow.

5. That in darkness the oxidation is considerably retarded; starts later and progresses more slowly than in light.

6. That the presence of certain materials, and the contact with certain substances, accelerate or retard this effect.

7. That in the resinification of oils there is both a loss of carbon and hydrogen of the oil, and an absorbtion of oxygen.

8. That the different oils, in oxidizing, furnish in general the same products: volatile acid compounds, liquid and solid fat acids not altered, and an insoluble solid material, which appears to be a definite proximate principle. Oils oxidized in the air no longer contain glycerine.

9. The drying and non-drying oils are not chemically distinguishable. All contain the same glyceric proximate principles, but in different proportions.

Graphotype.

From the London Mechanics' Magazine, December, 1865.

At the meeting of the Society of Arts held on December 6, Mr. H. Fitz-Cook read a paper on a new method of producing from drawings blocks for surface printing, without the aid of the engraver, to which the name of "Graphotype" has been given, and last week's number of the Society's *Journal* contains some illustrations printed from blocks produced by the new method. The new process is the invention of Mr. De Witt Clinton Hitchcock, one of the foremost draftsmen and engravers of New York, and was suggested by a little incident which Mr. Fitz-Cook thus related: "In the summer of 1860, Mr. Hitchcock, in the course of making a drawing on box-wood, found it necessary to alter a portion of his design by erasing it and rewhitening the exposed surface of the wood. The material used for this purpose was the enamelled surface of an ordinary visiting card, softened by water and a brush,—a method known to most draftsmen on wood. The card employed happened to be one printed from a copper plate, and after the removal of all the enamelling, as described, the artist discovered that the printed letters were undisturbed, and standing up in bold relief." His first attempt to carry out the idea, which this circum-

stance instantly suggested to him, was made upon a slab of chalk, sawn from an ordinary lump, and on one surface made as smooth a possible by scraping. He drew upon the smoothed surface of this piece of chalk with ink and a quill pen, using as ink silicate of potash, or "water glass," colored with indigo, and when the lines of the drawing were dry, he brushed away, by means of a tooth-brush, (but not using water, as when removing the enamel from a card,) all the portions of the chalk surface upon which there were no lines. "The lines of the drawing," we are told, "being literally composed of stone, withstood the assault of the tooth-brush, but the intervening particles of exposed chalk succumbed and vanished in a cloud of snowy dust, leaving the impregnable lines standing in relief, inviting a proof of their strength by printing on paper. This could not be done until the whole mass of chalk was changed into stone, by saturating it with the liquid glass, but in half an hour the chalk block was inked and printed in the ordinary way by burnishing." Ultimately, as the result of a great number of experiments, Mr. Hitchcock elaborated a process which seems likely to supersede wood engraving, if not for all, at least for many purposes, being much cheaper than wood engraving, and having, moreover, the great advantage of infallibly reproducing the artist's every touch, however delicate, with the most perfect accuracy. In its present shape, the process is conducted as follows: An artificial chalk block or plate is first produced by grinding the best French chalk to fine powder, mixing this powder with water to a thin cream, and separating the portion which precipitates first, repeating this operation several times in order to ensure the complete separation of any hard or coarse particles, drying the very finely divided chalk thus obtained and sifting it through wire-cloth, having 10,000 holes to the square inch, on to the surface of a perfectly smooth plate of zinc, placing a plate of highly polished steel on the top of the even layer of chalk flour thus obtained, and then submitting it to powerful hydraulic pressure. On removing the pressure and lifting off the steel plate, the chalk is found to be firmly attached to the zinc plate, and to present a pefectly smooth upper surface, which only requires to be "sized," in order that the ink to be used in drawing on it may not "spread," to be ready for the artist. The latter proceeds as in the ordinary method of drawing on wood, first making a red chalk tracing on the block or plate, and then, with sable hair pencils of various sizes, drawing his design line for line, exactly as he wishes it to appear when printed. The ink used is a mixture of glue and lamp-black, and dries instantly, so that one series of lines, of whatever thickness, may be immediately crossed by others. The drawing being completed, the portions of the chalk surface intervening between the lines of the drawing are disintegrated and removed, to the depth of an eighth of an inch or so, by means of brushes, some of them of fitch hair and others of silk velvet, and the chalk block is then hardened by being soaked in a solution of an alkaline silicate. A mould is then taken from the chalk block, and a type metal cast produced from this mould, by the ordinary processes of stereotyping, and it is this type metal

cast, and not the original block, that is used to print from. "The process is so delicate," says Mr. Fitz-Cook, "that the impression of the thumb wetted with the graphotype ink, skeleton leaves, feathers, and other objects of which nature printing has been applied, can be made to give beautiful impressions in the ordinary type press, whilst the finest hair line that the artist can make will stand equally well with the bolder work." The type metal cast may be obtained with ease within three hours after the completion of the drawing on the chalk surface, so that the new process has an immense advantage over wood engraving, not only as regards cost, but also as regards the time occupied between the completion of a drawing and that of the block by means of which copies of it may be multiplied by the printing press. While thus cheap and expeditious, the new process reproduces the artist's work with an absolute accuracy unapproachable by the most skilful engraver.

On the Decay of Gutta Percha and Caoutchouc. By Prof. WILLIAM ALLEN MILLER, M.D., F.R.S.

From the London Artizan, December, 1865.

Continued from page 131.

3. *Experiments on submarine cables.*—I have examined several specimens of cable from different lines which have been submerged for periods of time varying from a few weeks to seven years. In no case where the cable has been completely and continually submerged have I found any sensible deterioration in the quality of the gutta percha.

No. 1. Holyhead Irish cable, (from Captain Galton,) taken up in February, 1859, after seven years' submergence.

No. 2, *a*, *b*, *c*. Three specimens from the Dutch line, from Orfordness to Schevening, (Mr. L. Clark,) submerged five years, raised in August, 1859.

This cable was enclosed in a coating of galvanized iron wire, and contained a single wire of copper in gutta, bound round with hemp and tape soaked in boiled linseed oil, tallow, and Stockholm tar.

a. External coating of galvanized wire, not damaged by corrosion. This sample had been buried on the Dutch coast to a small depth in sand.

b and *c*. Outer galvanized wire much corroded, but the gutta percha quite sound. The gutta percha wire had, in each of these samples, been exposed to the air, out of the metallic casing, for some months, and consequently was dryer than the sample *a*, taken from its metallic coating just before it was analyzed.

No. 3. Cable off Portland, (Captain Galton.) Down for seven months; composed of seven thin copper wires twisted into a strand, covered with tar, then coated with gutta percha, without any metallic protecting envelope.

No. 4. Cable from line between Candia and Alexandria, (Captain Galton.) Construction similar to the last; it showed superficial erosions of the gutta percha after submergence for a few weeks, but the composition of the gutta was unchanged.

No. 5. New gutta percha covered wire, (Mr. L. Clark,) never used.

The only chemical difference perceptible in these different specimens was in the quantity of water mechanically retained in each.

100 parts of each contained—

	1	2			3	4	5
		a	*b*	*c*			
Water, . .	0·84	3·36	1·75	1·49	4·80	0·96	2·50
Ash, . . .	1·05	. . .	. . .	0·76	3·52	0·75	0·50

4. *Experiments upon damaged cables, suspended in air or placed underground.*—Of damaged cables I have had various specimens for examination.

1 to 6. Six examples described by Mr. Saward in his evidence before the Committee, January 12, 1860.

1. Buried in chalky or gravelly soil, coated with a white, friable crust of altered gutta percha. This was very brittle, and contained 35 per cent. of resin; this resin contained 17 per cent. of oxygen combined with a hydro-carbon of the same composition as pure gutta.

2. Was in soil exposed to leakage of gas pipes, and also was resinous and brittle, but less so than No. 1.

3. Was described as pulpy when raised, as if fermenting; taken from ground into which drainage from oak trees or posts occurred. When forwarded to me it was hard and tough, the copper wire within was slightly corroded and adhered to the gutta percha, the channel around the wire lined with a pale brown powder. This powder contained traces of copper. It appears to consist of gutta percha, as it was almost wholly soluble in benzol and was insoluble in alcohol. The material in this case seemed to have undergone comparatively little permanent change, although so very different in appearance from ordinary gutta percha, when it was taken up. It fused below 212°. It had been painted with some pigment containing lead, and on burning left an ash amounting to 1·87 per cent.

4. Not very brittle, taken from iron pipes.

5. Exposed to a dry heat near a baker's oven; coated with red lead.

6. Exposed to a dry heat, (exact source not indicated.) This was extremely brittle, could be powdered without difficulty, and was almost converted into a resinous substance. It fused below 212°, it left 1·03 per cent. of ash when burnt, and appeared to have been coated with some pigment.

In all these samples those which were most brittle contained the oxidized resinous body in largest proportion. This resinous substance varied somewhat in the proportion of oxygen which it contained in the different samples, but presented the same general properties. It was soluble in cold alcohol, and still more largely in boiling alcohol; was

insoluble in ether, and but sparingly in benzol; diluted alkaline leys dissolved it with facility, and the solution coagulated on the addition of an acid in excess.

7 and 8. Samples of gutta percha covered wire taken from a tunnel in the Stour Valley, placed in the tunnel in 1850, (Mr. L. Clark.) One portion of this, A, was comparatively little injured; the other, B, was brittle and rotten. This sample had been coated with some pigment containing lead.

It would be useless to cite in detail the various analyses which I have made of these several samples, or to give the numbers obtained for the proportion of moisture, ash, and resin which they contained, or to quote the proportions of carbon, hydrogen, and oxygen ascertained to exist in the altered portion, as contrasted with the unchanged portion, present in each sample.

It may be stated generally, that wherever the proportion of resin was greatest, the sample of gutta exhibited the greatest degree of brittleness; and this brittleness was always found to be most marked in the specimens which had experienced the greatest degree of oxidation; and further, that these changes appeared to occur most rapidly and decidedly in those points where the gutta percha was alternately wet and dry.

5. *Experiments on Caoutchouc.*—The caoutchouc of commerce is, like gutta, not a pure vegetable principle, and consists of a hydrogen composition, mixed with a small quantity of resin, the amount of which varies in different specimens.

The following are the results of my analysis of a sample of pure unmanufactured para rubber, compared with a sample of good sheet masticated or manufactured rubber:

	Virgin.	Masticated.
Pure caoutchouc, . . .	96·60	96·64
Moisture, ...	1·30	0·82
Resin, ...	1·80	2·06
Ash, ...	0·30	0·48
	100·00	100·00

Or, deducting moisture and ash, its elementary composition gave:

	Virgin.	Masticated.
Carbon, ...	85·82	85·53
Hydrogen, ...	11·11	12·06
Oxygen, ...	3·07	2·41
	100·00	100·00

Caoutchouc, like gutta percha, is, as already stated, liable to deterioration by exposure to the action of oxygen in the presence of solar light, but the gum is less rapidly injured if exposed to their influence in the native state, than if it had been previously masticated. When subjected to the action of air excluded from light, it does not experience any marked change, even during very long periods. It is, however, important to observe that the masticated rubber is much more porous than the unmanufactured caoutchouc. When immersed in water, caoutchouc absorbs a much larger quantity of this liquid than gutta percha, and the masticated much more than the unmanufactured

or virgin rubber. I subjoin the results of my examination of some samples submitted to experiment by Mr. L. Clark.

A.—*Virgin para rubber, finest quality.*—500 grains of this was exposed in each experiment, in the form of a narrow tape-like strip of rubber, which had been stretched while hot and suddenly cooled. It was of a very pale brown color. The various samples were submitted to experiment at the end of October, 1859, and were examined nine months afterwards, (August 4, 1860.)

No. 1, which had been exposed in netting in the open air to sun and rain, had become blackened and rotten, but was neither sticky nor crumbled; had increased in weight 34·5 grains, or 7 per cent.

No. 2 was exposed to the air and light, but kept dry in a bottle placed mouth downwards; it had increased in weight 14 grains, or 2·8 per cent., by absorption of oxygen, and had become brown, soft, and sticky, especially in the parts most exposed to light. It gave up 11·81 per cent. of an oxidized, soft, and viscous resin in alcohol. The annexed analysis will give an idea of the composition of the resin thus formed:

Carbon, ...	67·23
Hydrogen, ...	9·54
Oxygen, ...	23·23
	100 00

The proportion of oxygen differs a little in different samples.

No. 3, which was exposed to diffused light in fresh water in an open bottle, had become white and opaque from the absorption of moisture, and had increased 86 grains, or 17 per cent., but it had experienced no other alteration in chemical properties, and when dried resumed its original characters.

No. 4, exposed in sea-water in an open bottle to diffused light, had absorbed 3·6 per cent. of its weight of water, but was only a little altered in appearance, not in chemical composition.

B.—*Masticated rubber, sheet, best quality.*—A similar series of experiments were made simultaneously upon mastical sheet caoutchouc.

No. 1, exposed to sun and rain, had collected into a sticky mass, which had lost its tenacity and elasticity.

No. 2, in the inverted bottle exposed to diffused light and air, had increased in weight 8 grains, or 1·6 per cent., and had collected into a lump, which was viscous, and had lost its elasticity, especially in the parts most exposed to the action of light. When treated with alcohol it was found to yield 12·64 per cent. of its weight of resinous matter to this solvent. These changes were in marked contrast to No. 3, which was kept in a glass bottle in the dark for the same period, but exposed to the air freely. It had increased in weight only 0·6 per cent., did not show any sign of alteration in tenacity or elasticity, and yielded to alcohol 2·0 per cent. of resin only.

No. 4, a sheet of the same rubber immersed in fresh water, open to the air and diffused light, had increased 87 per cent. by absorption of water; that is to say, it had nearly doubled its weight. It had become

white, opaque, slimy, and sticky when pressed, and allowed water to be squeezed out by pressure. It lost weight rapidly by drying when exposed to the air.

No. 5, similar to the last, but exposed in sea-water. It was slightly opaque and slimy, but had increased only 5 per cent. in weight by absorption. A second sample, in sea-water in a closed bottle, emitted a smell of sulphuretted hydrogen, and had gained 5·6 per cent. in weight by absorption. Its elasticity and tenacity were not impaired. The gradual permeability of masticated caoutchouc to water was further strikingly shown by enclosing a quantity of acetate of potash in bags made of sheet rubber and accurately sealed. They were then immersed in water, and at the end of nine months the salt in each of the bags was found to have become liquefied by the water which it had absorbed, and the bags had in each case gained in weight several grains.

C.—*A similar series of experiments made with sheet rubber, vulcanized.*—1. The sheet exposed in the netting to the sun and rain had lost 2 per cent. in weight; it was scarcely less tenacious than at first.

2. A similar sheet in fresh water absorbed 19 per cent., but was not otherwise altered.

3. A similar sheet in sea-water was rather more slimy, and had only gained 1·6 per cent. in weight.

Each of the three substances, viz: natural, masticated, and vulcanized rubber were submitted to the action of the following solvents for nine months:

A. Boiled linseed oil.
B. Unboiled linseed oil.
C. Stockholm tar.

The *virgin rubber* had resisted the action of the solvents almost perfectly, retaining its toughness, excepting in those parts which were above the surface of the liquid and exposed to light. In the tar, this rubber had contracted spontaneously, but was still strong and elastic.

The *masticated rubber* was, in each instance, greatly swollen and gelatinized, and indeed, in the case of the unboiled oil, was completely dissolved.

The *vulcanized rubber* had also lost its tenacity, and had become swollen and gelatinous, but retained its form and a certain degree of elasticity.

A sample of india rubber cable (from Captain Galton,) which contained six strands of copper wire, each coated with rubber, then bound round with tape and again with rubber, had experienced a singular change, having become, *where in contact with the wire*, quite glutinous and sticky. This change, however, did not progress in the specimen which I kept for some months in my room, but the viscosity, on the contrary, gradually diminished.*

* The quantity of viscous matter was too small to admit of satisfactory analysis. I ascertained, however, that no copper was present in the viscous mass, and that the wire was not corroded. I could not determine whether grease was present in small quantity, as was not unlikely.

6. *Experiments on other substances.*—An insulating mixture composed of gutta percha, shellac, and powdered glass or clay, known as "Wray's Compound," (from Captain Galton,) was also submitted to experiment.

Heated to 212° it softened, but retained its shape. It lost by drying 0·5 per cent. of moisture, and when burnt left 22 per cent. of a white ash, chiefly silicate of alumina. This compound absorbs water but sparingly. 500 grains left in fresh water for six months increased 7·5 grains in weight, or 1·5 per cent., and a similar increase in weight occurred in another experiment where *sea-water* was used.

Sample of gutta percha cable (from Captain Galton) vulcanized by Mackintosh's patent.—The wire was found to be blackened on its surface from the action of the sulphur, owing to the formation of sulphide of copper, and traces of copper were found in the gutta percha covering.

On some of the most Important Chemical Discoveries made within the last Two Years. By Dr. F. Crace Calvert, F.R.S., F.C.S.

Lecture I.

From the London Journal of the Society of Arts, No. 671.

On the Discoveries in Chemistry Applied to Arts and Manufactures.—In this lecture I intend to treat of chemistry applied to the arts, and more especially to some of the discoveries which have been made within the last two years. Many of these will appear to you to be incomplete, but if complete they would not be new, for seldom are discoveries perfected at once. They are generally the result of many years study, and of the thoughtful consideration of several men.

The first part of this lecture will have reference to some of the applications which the laws of light have received during the last few years; and it will, I hope, convince you of the necessity of every one engaged in the arts making himself acquainted with all the laws connected with the phenomena of light, to enable him to appreciate the discoveries which have been made, or to assist him in improving upon those which are already known, as they are constantly receiving the most valuable applications in the arts and manufactures. Thus, for example, M. Donné has applied the properties of light to ascertain the relative values of milk by the amount of cream they contain, and this he effects by an instrument which he calls the lactoscope. Dubosch Soleil has applied with great success one of the most complicated laws of light, viz: polarized light, to the commercial estimation of the various qualities of sugars. By this process the sugar refiner, or any other person interested in that product, is enabled to ascertain in half an hour exactly the amount of crystallized sugar there is in a given sample, as compared with the quantity of non-crystallizable, or what is commonly called treacle. M. Dubosch Soleil's apparatus is considered so accurate that the French government has adopted it to determine the value of raw sugars imported into the country, and the

customs duties are levied upon the results given by this instrument. I may further add that this apparatus, called "Polarizing Saccharometer," is based on the peculiar property which light has when polarized, or when its rays are received at an angle of 35° 25′ degrees on a plate of tourmaline or a mirror. M. Dubosch Soleil's apparatus enables him to work with polarized light, which presents the various colors of the spectrum in such away as to enable him thereby to determine, as I have already stated, the amount of crystallizable sugar in any given quantity of the article, sufficiently accurately for all commercial purposes.

It is impossible for me, in a single lecture, to attempt to give you an idea of the various improvements which have been effected, even within the last two years, in the arts of photography, talbotype, photozincography, glyphography, or other processes which are due to the action of light on sensitive surfaces; but you will find an excellent paper on the application of photography, and also of light to sensitive surfaces as applied to the art of engraving, in vol. xiii., page 131, of this *Journal*, by Mr. S. T. Davenport, under the heading of "Engraving and other Reproductive Art Processes." Still there are two discoveries which appear to me to deserve passing notice, viz: the carbon process of Mr. Swan, and also the process discovered by M. Villème, and now carried on in London by a company, by which the operator is enabled not only to take the photograph of a person, but to produce a statuette giving a full representation of the figure itself, and a far more accurate personification than could be produced by any sculptor, and that at a cost of as many shillings as the sculptor would expect pounds. But the most important series of researches which have been made of late years in connexion with photography, and to which I deem it my duty to call especial attention, are such as to acquire more and more importance as they are more developed. I therefore feel convinced that any one who will devote his talents to the study of this particular branch of photography, will in time be amply rewarded, and of this there can be no doubt, when we consider the results already obtained by the labors of only two or three gentlemen. I refer to the reproduction of the various colors of the spectrum upon sensitive surfaces. In 1838, Herschel was the first to publish a paper on the various colors which chloride of silver is susceptible of taking under the influence of certain colored rays of light. Mr. Robert Hunt also published, in 1840, a paper referring to the subject; but the most complete series of researches on the subject of the reproduction of the colors of the spectrum, and which led to a process by which several of the colors of the spectrum could be reproduced on a sensitive surface, is due to Edmond Becquerel. The results arrived at by this gentleman were so remarkable that they drew the attention of the whole scientific world; and the following is an outline of the processes which were applied by him to obtain this interesting result. He took a daguerreotype plate or a silver-plated one, and having dipped it in a weak solution of chlorine, or, what was still better, a weak solution of hydrochloric acid, by connecting it with the poles of a battery, the

brilliant silver surface acquired different tints, passing gradually from an opaque white to a black tint. He also observed that the tint best suited to obtain favorable results was when the plate had acquired a pearlish pink; and although he found that the plate so prepared, when placed in the camera obscura, assumed the colors composing the spectrum, still they were faint, but he remedied this defect of intensity of tints by heating for several hours to a temperature of 95° to 100° the chlorinated plate, and then submitting it to the influence of the various colors composing the spectrum. Further, in the course of his studies he made the important observation that he could replace the peculiar action of heat on his prepared daguerrotype plate by exposing it to the rays of the sun under a sheet of paper which had been steeped in an acid solution of sulphate of quinine. The effect of this was that the plate of silver assumed an intense white color, nearly resembling that of paper; whilst if the protective paper had not been used, the silver plate would have gradually acquired a dark tint, and would have lost the whole of its sensitive properties, the protective paper having the power of arresting completely the most refrangible rays of light, especially those which are beyond the line H of the spectrum. Notwithstanding M. Edmond Becquerel's ardent hopes to find a method which would enable him to fix on a sensitive surface the various colors of the spectrum, still he failed, for they faded immediately after they were exposed to the direct rays of light, and could only be preserved in obscurity. But there is one gentleman who deserves great praise for the extraordinary perseverance which he has shown in this class of investigation. I mean the nephew of the discoverer of photography, M. Niépce de Saint Victor. Although I will not enter here into the details of these valuable researches, as they can be found in the *Comptes Rendus de l'Académie des Sciences*, still I may just be allowed to state that he has not only, by the following process, obtained far more brilliant colors than those first produced by M. Becquerel, but has succeeded in reproducing on sensitive plates the various colors of colored surfaces, such as are presented by fabrics, flowers, &c., and further, he has lately been so fortunate as to reproduce on his plates, yellow and black tints, which had resisted all previous attempts. To give you an idea of the facts arrived at by this gentleman, I may state, that he has succeeded in so fixing upon sensitive surfaces the various colors of the spectrum, or of colored surfaces, that they will bear the action of diffused light for several days. In fact, I have seen photographs, which reproduce faithfully, a small doll dressed up in various colors, and in which even the most minute ornament could be traced, and, what is certainly not less interesting, was the reproduction of the irridescent colors of the peacock's feather. To obtain these marvellous results, M. Niépce de Saint Victor takes a daguerrotype, or silver coated plate, and dips it into a weak solution of hypochlorite of sodium, having a specific gravity of 1·35, until it has assumed a bright pinkish hue. The plate is then covered with a solution of dextrine, saturated with chloride of lead; it is then dried, and subsequently submitted to the action of heat, as in M. Becquerel's experiment, or under the

screen of sulphate of quinine also referred to above. The plate is then ready to be placed in the camera obscura, and to receive the colors of the spectrum, or representations of nature, such as flowers, as well as certain colors produced by man. Lastly, he succeeds in increasing the stability of the colors developed on the sensitive surface by covering the plate with an alcoholic solution of gum benzoin, and M. Niépce gives the name of Helio-chromie to this branch of photography.

During his lengthened researches, M. Niépce de St. Victor has made two series of observations which I deem it my duty to lay before you, viz: that he can produce with facility, on prepared plates, the binary colors of the spectrum, viz: orange, violet, indigo, and green, if those colors are natural; but if they are artificially produced by the mixing of two of the primary colors, as red and yellow, or orange and blue, and yellow or blue, he cannot produce the binary color, but only one of the two colors employed by the artisan to prepare them. Thus, for example, he can reproduce the natural green of malachite, and the beautiful color known as Scheele's green, but he cannot do so with a mixture of Prussian-blue and yellow chromate of lead, the blue only reappearing. These facts enable him to explain why, in ordinary photography, the leaves of plants always appear black, and why, when he attempts to fix on his plates the colors of leaves, they have a bluish hue, the yellow portion of the color not being reproducible.

M. Niépce has made another series of observations which deserve notice, viz: that when a plate, as prepared by his process, is dipped in an alcoholic solution of substances susceptible of imparting a color to flame, such, for example, as strontia, which communicates a red hue to it, or baryta, which gives a yellowish-green color, the prepared plates, when exposed in the camera, will assume the same color as the salt which they have on their surface would impart to the flame of alcohol; and if a salt of copper be used, which has the property of communicating a variety of tints to the flame of alcohol, the plate also will assume a variety of tints when exposed to the action of light; and during a certain period of his lengthy researches M. Niépce availed himself of this curious phenomenon to obtain colored plates in the camera. They are not only interesting as reproductions of art, and as a feat of extraordinary skill in the progress of photography, but they are especially so because in time they will lead to methods which will enable us to communicate to our little children perfect and correct views of our time, and other interesting facts connected with the period in which we live.

All persons interested in the progress of photography will find full details of the new processes for reproducing vitrified photographic plates in vol. lx., page 1239, of the *Comptes Rendus de l'Académie des Sciences*, 1865. These I omit, as they are purely technical, and have only an interest for those immediately engaged in that branch of the photographic art.

I shall now have the pleasure of calling your attention to a most important series of researches published by Professors Bunsen and

Roscoe; but, to enable you to appreciate their value, it is necessary that I should make the following remarks: It is now well known that the solar spectrum is composed of three primary colors—blue, yellow, and red; and, also, of four complementary or binary colors, viz: orange, green, indigo, and violet. It is also known that those colors represent different properties or qualities of that universal fluid called ether, which, I may say, was generalized by Sir Isaac Newton under the name of gravitation, on which the whole of the planetary system is based, and which gives to the universe its harmony and stability. This fluid is susceptible, under certain influences, as those generated by the sun, of being set in vibration, and thus are generated heat, light, and chemical rays; and further, as there is no chemical action without a corresponding production of electricity, it follows that electricity, as well as magnetism, may be considered as a mere modification in the vibrations of the same fluid. Therefore we may truly say that all the imponderable fluids called light, electricity, heat, magnetism, and force have all the same origin, namely, the fluid called ether and which, according to the nature of the vibration, developes or renders palpable to our senses one of those fluids. In fact, I feel convinced that this unique fluid is not converted into those divers fluids by special modifications of its own vibrations, but that they only become manifest to our senses when it has imparted its own or special vibration to the particles of matter, and that it is the peculiar vibration which it imparts to the molecules of matter that developes in the molecules themselves such a mode of vibration as gives birth to what we call light, electricity, magnetism, heat, and force. In fact, there is no doubt, from the researches of Dr. J. P. Joule, Professors William Thomson, Mayers, and others, that heat and force are the same fluid, for Dr. Joule has given us the exact measurement of that force. He has demonstrated that the amount of heat necessary to raise one pound of water one degree in temperature, would, if applied mechanically, be competent to raise one pound weight 772 feet high, or it would raise 772 pounds one foot high. The term "foot-pound" has been introduced to express in a convenient or systematic way the lifting of 772 pounds to the height of one foot. Thus the quantity of heat necessary to raise the temperature of a pound of water one degree being taken as a standard, 772 foot-pounds statute, is what is called the mechanical equivalent of heat. Dr. Tyndall in his valuable work on "Heat considered as a Mode of Motion," gives many interesting examples of the conversion of heat into force, and *vice versa*. For example, he cites the following theory of Professor Thomson, who assumes that an immense amount of force is converted into heat when meteoric matter is attracted to the surface of the sun by the molecular attraction called gravitation; that the force generated by the immense velocity with which meteoric matters travel towards the sun, becomes converted instantly by its contact with the sun into heat; and further, he considers, that the showering of meteoric matter, as well as that of the zodiacal lights on the sun's surface, are sufficient to account for the immense heat which he supposes the sun's surface to

possess. I must say that I do not believe the sun possesses much heat or light; I believe that it is only an immense mass which, by its size as compared with the rest of the planetary system, becomes the centre of gravitation; and that there exists between it and the planetary bodies a constant state of attraction; that the fluid called ether, which represents the force called gravitation, is in a constant state of activity throughout the universe, and brings about that Godly and admirable harmony which pervades it; and although the ether filling space can be considered in a constant state of action or vibration, and convertible into the fluids which we call heat, light, electricity, and magnetism, still these fluids only become manifest to our senses when they put into vibration the particles of matter, or produce, according to their peculiar vibration, the phenomena of light, electricity, magnetism, heat, and force; for if heat is convertible into force, as asserted by the researches of the eminent *savants* above stated, why should not the production of other fluids be due also to similar phenomena? If it be true, as Joule, Thomson, and others contend, that force and heat are due to the vibration of the molecules of matter, and that according to the rapidity of the vibrations of such atoms (imparted to them by the vibrations of ether) one or other of these forces is engendered, why should not the manifestations of other fluids be traced to similar causes? In fact, no doubt can exist in my opinion with respect to electricity and magnetism, for if their manifestations to our senses were owing to the vibration of a universal force, it would affect all bodies in the same way and in the same degree. Now, this is not the case; for there are good and bad conductors. Therefore it follows that the atoms composing matter, or more so, their nature, have an influence on its degree of manifestation. The same with magnetism; for we find oxygen to be magnetic, and nitrogen non-magnetic or diamagnetic. Thus it appears to me from these facts, which might be multiplied if time permitted, that the manifestations of heat, force, electricity, and magnetism are not peculiar and distinctive fluids, but are due to the modification in the mode of vibration of the universal fluid called ether, which imparts to matter its peculiar undulations, and that these forces are only made manifest to us when the vibrations come into contact with solid matters, such as compose the atmosphere or the earth. Therefore, I am of opinion that there is no light, heat, electricity, or magnetism beyond the limits of the atmosphere which surround the earth; but that when the ether, which is in a state of vibration, comes in contact with the particles of matter composing our atmosphere, it then communicates one of its own peculiar vibrations to these particles; then they, by their vibrations, become luminous. If this theory is correct, it follows that the production of the phenomena of light is due to the vibrations of solid matter, and not to the vibrations of the ether, as is assumed by the philosophers of the day.

I very well know that these views of mine are completely in contradiction with those entertained by most of the philosophers of the day; but still I hope to be able to publish a sufficient number of scien-

tific researches, as well as to draw attention to such a number of physical, chemical, and astronomical facts as may, even if not proving the truth of my views, at all events, I hope, deserve some attention.

Now, let us return to the subject under consideration, viz: that a spectrum is produced by the decomposition of light when it is refracted at an angle of 60°; and that the result of that decomposition is the production of three primary and four binary or complementary colors. Further, that the red portion of the spectrum represents calorific rays of light; that the green and yellow represent light-giving rays, and violet and the rays beyond it the chemical or actinic rays of the same. Philosophers have for a long period been able to measure accurately the intensity of the heat-giving rays, by means of a thermometer or the thermo-electric pile; and though we had a general knowledge of the intensity of the chemical rays of light, still we had no method of accurately measuring its real intensity, and conveying our results and observations to others, till Professors Bunsen and Roscoe filled up this important gap. These gentlemen's researches will be of great service to science and to society, as they will throw much light on many meteorological data, and enable a chemist to study with more precision than has been previously done the chemical phenomena of vegetation and other phenomena connected with the chemistry of agriculture. For example, the thermometric observations giving the mean monthly or yearly temperature of a country, by no means yield all the data required for the estimation of the true climatology of the place, or of its plant or animal producing capabilities. For these purposes we require to have not only the amount of solar heat directly or indirectly reaching the spot, but likewise the amount of chemical active solar light which may be present there. This is strikingly exemplified by the following example given by Dr. Roscoe on a comparison of the mean annual temperature between Thorshawn, north latitude, 62° 2′; west longitude, 6° 46″; temperature, 45° 6′; and Carlyle, north latitude, 54° 55′; west longitude, 2° 58″; temperature, 46·9; difference 1·3. From these figures it will be seen that the mean annual temperature is nearly equal, but the quantity of sunlight falling upon those two places differs most widely, and we have a corresponding difference in true climatological results. Thus the flora of the Faroe Islands and the Shetland Islands is of a most limited description. Only hardy varieties of shrubs, and no trees or flowers, exist there, while at Carlyle we have a luxuriant vegetation accompanying a most sunny sky. How essential, then, are the rays of light to vegetation. These gentlemen have also ascertained that those rays are in ratio with the intensity of that light; and still further, they are also in ratio with the chemical or actinic rays of the sun; and thus the researches of these savants will enable them to measure with accuracy those chemical actions. It is impossible, in a lecture like this, to render justice to their researches; therefore I must refer those who wish to consult them to the *Philosophical Transactions of the Royal Society*. Still I may state that these gentlemen's photochemical instruments are based on the following data, namely, that

equal intensity of light produces in the same given space of time equal shades of tint on surfaces prepared with chloride of silver of uniform sensitiveness. Thus it is shown by experiments that a tint attained by paper so prepared is constant when the quantity of light falling upon it also remains constant. Light of an intensity of 50° falling upon a paper for the time of one minute produces the same blackening effect as light of the intensity of one falling upon it for the time of 50 minutes. Knowing these laws which regulate the degree of shade of the paper, and having a surface of a perfect constant degree of sensitiveness, it is easy to obtain the absolute measurement of the chemical action of light.

(To be continued.)

For the Journal of the Franklin Institute.

Official Preliminary Report of the Results of the Trial on Long Island Sound between the U. S. Steamers Winooska and Algonquin.

GENERAL INSPECTOR'S OFFICE,
STEAM MACHINERY, U. S. NAVY,
New York, February 19, 1866.

SIR: The undersigned, appointed by you to conduct the experiments with the competitive machinery of the U. S. paddle-wheel steamers *Winooska* and *Algonquin*, have the honor to submit the following preliminary report of the results of the trial on Long Island Sound for maximum power of machinery and speed of vessel, and for economy of fuel under these conditions. It will be followed by a full report, embracing the results of all the experiments at the wharf, as well as that on Long Island Sound, together with our conclusions from the same, and all the data *in extenso:*

The trial on Long Island Sound was intended to embrace eight consecutive double runs between Execution Rock Light-house and Faulkner's Island Light-house, passing around both. Each double run, measured on the vessel's track, was, according to the Coast Survey Chart, one hundred and thirteen (113) geographical miles; but a violent storm, accompanied with weather so thick as to prevent the lights from being visible beyond a mile or two, and the refusal of the pilots to run in it, terminated the trial after the *Winooska* had performed three (3) double runs, or 339 geographical miles, and the *Algonquin* two double runs, or 226 geographical miles. Our data and results are, accordingly, for these distances, respectively. Both vessels ran a portion of the distance on the next run, but that portion is omitted because the exact position of the vessels could not be determined when it was decided to anchor.

During the running time the water was smooth and the wind a gentle, variable breeze. At each terminus of the route a large field of ice was encountered, whose resistance greatly lessened the speed of the vessels while passing through it, and their speed was also decreased

by the turning of the vessels around each terminus. Neither vessel steered well, but they were about equal in this particular, which, of course, still further lessened their speed.

The machinery of both vessels was in excellent order; that of the *Algonquin*, after the completion of the wharf trials, had been for two months and a half in the hands of the contractor for repairs, during which he had renewed all the vertical tubes of the boilers, substituted a new circulating pump, etc., etc. In the course of the trial the feed pump, worked by her main engine, was inoperative ten and a half (10½) hours, during which time the boilers were supplied by the auxiliary steam pump. As, however, this pump drew the feed water from the hot well, its substitution in no way affected the performance of the machinery. The counterbalance of the eccentric broke during the trial, but its fracture was not of the least importance. A paddle on one of the wheels was also broken, but it took place on the return of the vessel to port, and not during the trial.

With the machinery of the *Winooska* there were no accidents or derangements, and it functioned throughout with the same regularity, noiselessness, and smoothness of motion, which characterized its previous performances at the wharf.

On board the *Algonquin* the blower was used, but as it delivered the blast into an open fire room, its effect must have been very small. The steam jet in the smoke pipe was in use, and, with the boiler pressure of nearly 68 pounds per square inch above the atmosphere, was doubtless very efficient in forcing the draft.

On board the *Winooska* the blowers were not used. They are two in number; each is driven by an independent steam cylinder, and delivers its blast into the ash-pits of the boilers, which are closed by air-tight doors. When employed, an enormous rate of combustion can be commanded, and a supply of steam much exceeding that used during the trial. A steam jet (the duplicate of the *Algonquin's*) in the smoke pipe was employed during the trial with a boiler pressure of 38 pounds per square inch above the atmosphere.

The machinery of both vessels was fitted with surface condensers, and neither was obliged to "blow off" during the trial. The vacuum in the *Algonquin's* condenser was less than that in the condenser of the *Winooska*, but as it resulted from inefficiency of condensing surface, and not from air leaks, it was attended by a correspondingly high temperature of feed water, which, to a great extent, compensated this disadvantage.

At the commencement of the trial the *Algonquin's* draft of water was 8 feet 5 inches forward, and the same aft; while the *Winooska's* draft of water was 8 feet 10 inches forward, and 8 feet 8 inches aft. The difference of 4 inches in the mean draft was an allowance made for the deeper false keel of the latter vessel, both vessels being presumed to be in other respects identical, as they were constructed from the same building directions and mould loft dimensions.

The paddle-wheels of the *Winooska* consisted each of twenty-four (24) paddles. Each paddle was 9 feet in length and 16 inches in

breadth, and its outer edge was placed at the distance of 12 feet from the centre, making the diameter over the paddles 24 feet. The total area of paddle surface in one wheel was 288 square feet. With the vessel at the above draft of water, the deepest immersion of the outer edge of the paddles was 3 feet 6 inches.

The paddle-wheels of the *Algonquin* were arranged by the contractor as he desired. Each wheel consisted of thirty-six (36) half paddles, eighteen on each side, and placed opposite the interspaces of those on the opposing side. These half paddles would have been equi-spaced had each wheel consisted of forty eight of them instead of thirty-six; but, by the omission of twelve, six at diametrically opposite points, an empty space equal to that due to three paddles so spaced was left at those portions of the circumference of the wheel. All the half paddles were of the same length, namely, 5 feet, but they were of unequal breadths, being so made and arranged on the circumference of the wheel for the purpose of producing a regular rotary motion with the high pressure steam and high measure of expansion used. The breadths of the consecutive half paddles in inches were as follows, namely: 15, 17, 19, 21, 24, 27, 24, 24, and 21. The length from outside to outside of a pair of half paddles was 9 feet, caused by their overlapping one foot at the centre. The total area of paddle surface in one wheel, taking the length of a pair of half paddles at 10 feet, is 320 square feet; and taking their length at 9 feet, 288 square feet. The inner edge of all the paddles was at the same distance from the centre, namely, 10 feet 8 inches, which made the mean distance of their edges 12 feet $5\frac{1}{3}$ inches from the centre, or the mean diameter over the paddles 24 feet $10\frac{2}{3}$ inches. With the vessel at the draft of 8 feet 5 inches, forward and aft, the mean deepest immersion of the outer edge of the paddles was 4 feet 6 inches.

The boilers of the *Winooska* contain 200 square feet of grate surface, and 5036 square feet of heating surface, and had no means of superheating the steam. The boilers of the *Algonquin* contained 144 square feet of grate surface, and 2678 square feet of heating surface, together with 1132 square feet of steam superheating surface in tubes. The boilers of both vessels have water tubes. In the *Winooska* they are vertical and are arranged above the furnaces according to Martin's patent, and in the *Algonquin* they are inclined and arranged in combination with the superheating tubes, according to the patent of Mr. E. H. Dickerson, who designed the entire machinery of that vessel.

Each vessel has one inclined and direct acting engine. The cylinder of the *Winooska* is 58 inches in diameter, and its piston has a stroke of 8 feet 9 inches. The cylinder of the *Algonquin* is 48 inches in diameter, and its piston has a stroke of 10 feet.

The space occupied in the *Winooska* by the machinery and coal is 67 feet 11 inches long, by the entire breadth and depth of the vessel, and in this space there is a coal bunker capacity of 9424 cubic feet. The space occupied in the *Algonquin* by the machinery and coal is 75 feet 5 inches long, by the entire breadth and depth of the vessel, and in this space there is a coal bunker capacity of 6931 cubic feet.

The weight of the machinery of the *Winooska*, exclusive of water in the boilers, is 541,718 pounds, and inclusive of the water 623,718 pounds. The weight of the machinery of the *Algonquin*, exclusive of water in the boilers, is 629,144 pounds, and inclusive of the water 701,144 pounds.

The distribution of the weights of the *Algonquin's* machinery was so excessively faulty, that when the vessel was fully stowed for sea, with her coal bunkers filled, water in boilers, etc., she had a list of 22 inches to port, giving her port paddle-wheel an immersion of 7 feet 3½ inches, and her starboard paddle-wheel an immersion of 3 feet 7½ inches. To bring the vessel upright there was required a weight of 73 tons to be stowed on the berth and spar-decks in the extreme wing, after the hold had been restowed in such manner as to place all the weight possible on the starboard side. This additional weight of 73 tons required to be continually trimmed as the coal was used from the bunkers; of course, it added just that number of useless tons to the vessel's displacement, and if it be added to the weight of the machinery, to which it was simply a counterbalance, it will swell that weight to 866,664 pounds.

The following are the principal dimensions of each vessel; the greatest immersed transverse section and the displacement corresponds to their drafts of water at the commencement of the trial:

Depth from lower edge of rabbet of keel to mean load-water line,	8 ft. 2¼ ins.
Length on mean load-water line from the forward side of the rabbet of stem to the after side of the rabbet of the stern post,	240 ft.
Extreme breadth on mean load-water line,	35 ft.
Displacement,	1280·78 tons.
Area of the greatest immersed transverse section,	263·85 sq. ft.

On commencing the trial in Long Island Sound, the vessels started abreast at Execution Rock Light-house, after having steamed from the Brooklyn Navy Yard to that point. The machinery of the *Algonquin* was operated by four engineers from the merchant service employed by the contractor for that purpose; the naval engineers on board merely took the data of the performance, but in nowise interfered with the management of the machinery, which was exclusively in the hands of the contractor's engineers.

During the time the machinery of both vessels was in operation, a complete steam-log of the performance was kept, in which was noted in proper columns, at the end of each hour, the number on the counter, the number of revolutions made by the engine per minute during the hour, the steam pressure in the boiler and in the main steam pipe near the engine, the vacuum in the condenser, and the position of the throttle valve, the temperature of the atmosphere on deck, of the engine room, of the fire room, of the injection water, of the discharge water, and of the hot well or feed water; also, the height of the barometer in the engine room. An accurate account was kept of the coal thrown into the furnaces each hour, and of the refuse therefrom withdrawn from the furnaces and ash-pits at the end of each watch of four hours. At the end of every half-hour an indicator diagram was taken from each end of the cylinder, and the complete data marked

on it at the time of taking, such as number of revolutions of the engine per minute, steam pressure, vacuum, &c. A naval engineer was always on watch in the fire room and in the engine room of each vessel, making two engineers to a watch.

In the table hereunto appended will be found the totals and means of all the above quantities and the calculated results therefrom.

The point at which the steam valve of the *Winooska* closed and cut off the admission of steam to the cylinder, was, measured on the main crosshead guides, 6 feet 4 inches from the commencement of the stroke of the piston on the lower stroke, and 6 feet in the upper stroke. The mean point of cutting off was, therefore, at seven-tenths ($\frac{7}{10}$) of the stroke of the piston from the commencement. As the cut-off of the *Algonquin* was not a positive one, the point of cutting off was obtained from the indicator diagrams and is the mean given by them.

The following are the guarantees of the contract for the machinery of the *Algonquin*, and it was the object of the trials at the wharf and in Long Island Sound to ascertain if they were fulfilled, and if not, to what extent they were deficient:

1. "That all the materials, workmanship, detail, and finish shall be first class."

2. "That the whole performance [shall be] of such a character as to demonstrate the satisfactory strength, reliability, practical efficiency, and durability of the entire machinery."

3. "That the variations from the specifications [those of the machinery of the *Winooska*] hereunto attached, [to the contract for the machinery of the *Algonquin*,] and forming part of this contract, are to be in the dimensions and arrangements of the cylinder and such parts as are thereby affected in the design of the valve gear, and in the type and arrangement of the boilers, and also in the surface condenser. These changes are not to increase the weight of the machinery, nor the space occupied by it, nor to decrease the weight of coal carried in bunkers within the limits allowed for the engineer department with the machinery described in the attached specifications," [that is the specification for the *Winooska's* machinery.]

4. "That if on the completion of the machinery, and a careful trial thereof, by such persons as may be directed by the Secretary of the Navy, it shall be found by them that its performance, either in amount of power developed, or in the cost *pro rata* of that power in coal, is less than those of the machinery described in the attached specifications, [the specifications for the *Winooska's* machinery,] they, the said parties of the first part, [the contractors for the *Algonquin's* machinery,] will remove it and replace it at their own cost with the machinery described in the attached specifications."

The contract for the *Algonquin's* machinery also provides that, "The entire responsibility of fulfilling the guarantees is to rest with the said parties of the first part, who will make their own working drawings, and arrange and proportion the details of the said machinery in such manner as they shall deem best calculated to secure the most successful operation."

With regard to the first and second of the above guarantees, we have to say that, in our opinion, they have not been fulfilled. The *Winooska's* machinery has worked in the most perfect manner throughout, and its performance in every particular leaves nothing to be desired for efficiency in a paddle-wheel steamer. Its durability and reliability could be depended upon for any length of cruising. Its workmanship, material, finish, accessories, and appointments, are first-class throughout. The machinery of the *Algonquin* is wanting in these particulars, and in proper adaptation for marine purposes. In style, finish, and conveniences for manipulation, and in accessories and appointments, it is much inferior to that of the *Winooska*.

With regard to the third guarantee, we find the machinery of the *Algonquin*, including water in boilers, to be 77,426 pounds heavier than the machinery of the *Winooska*, including water in boilers. This excess of weight is one-eighth of the weight of the *Winooska's* machinery. If to it be added the 73 tons of extra ballast required to keep the vessel upright on account of defective distribution of the machinery, the excess of weight for the *Algonquin's* machinery will be 242,946 pounds, which is 39 per centum of the weight of the *Winooska's* machinery. This excess of weight requires about 8 inches of draft of water to furnish the necessary displacement for it, and, of course, greatly lessens the value and efficiency of the vessel.

The space occupied in the length of the vessel by the machinery and coal of the *Algonquin* is 7 feet 6 inches greater than the corresponding length in the *Winooska*. This is equivalent to 11 per centum of the space occupied by the machinery and coal of the *Winooska;* yet, in the larger space thus occupied in the *Algonquin*, there is only 6934 cubic feet of coal bunker capacity, while in the lesser space occupied in the *Winooska* there is 9424 cubic feet of coal bunker, the *Winooska* thus carrying 36 per centum more coal than the *Algonquin*.

The contractors have therefore signally failed in fulfilling the third guarantee.

With regard to the fourth guarantee, we find that the machinery of the *Algonquin* developed only 54·29 per centum of the power developed by the machinery of the *Winooska*, and that the cost of the indicated horse power in pounds of anthracite consumed per hour with the machinery of the *Algonquin* was 18·58 per centum more than with the machinery of the *Winooska*, taking that of the latter for unity. If the comparison be made, as it properly should be, for economy of fuel, by taking the combustible matter of the coal instead of the coal itself for the expression of the cost of the power, as the per centum of refuse in ashes and clinker is an accidental and variable proportion, then the cost of the indicated horse power in pounds of combustible consumed per hour with the machinery of the *Algonquin* was 23·28 per centum more than with the machinery of the *Winooska*. In this most important guarantee for amount of power and economy of fuel, the failure of the contractors is the greatest of all, resulting in a loss of speed of nearly two geographical miles per hour, and a large increase of the cost of the steam power, *pro rata*.

In every point guaranteed by the contractors for the *Algonquin's* machinery, they have failed, and we are of opinion that it is totally unfit for the naval service.

The steam logs of the experiment and the indicator diagrams are herewith forwarded.

Respectfully submitted by, sir,

Your obedient servants,

ROBERT DANBY,
EDWIN FITHIAN,
MORTIMER KELLOGG,
Chief Engineers U. S. N.

HON. GIDEON WELLES, *Secretary of the Navy.*

DATA AND RESULTS *of the trials of the U. S. Paddle-wheel Steamers* "WINOOSKA" *and* "ALGONQUIN," *on Long Island Sound, between the Light-houses on Execution Rock and Faulkner's Island, to ascertain the relative amount of power developed by the machinery of the respective vessels and the cost of the same,* pro rata, *in fuel.*

	WINOOSKA.	ALGONQUIN.
Date of commencing trial,	3 PM, Feb 13, '66.	3 PM, Feb 13, '66.
Vessel's mean draft of water at commencement of trial, in feet and inches,	8 ft. 9 ins.	8 ft. 5 ins.
Vessel's greatest immersed transverse section, in square feet,	263·85	263·85
Vessel's displacement, in tons,	1280·78	1280·78
Mean immersion of outer edge of paddles at commencement of experiment, in feet and inches,	3 ft. 6 ins.	4 ft. 6 ins.
Duration of the experiment, in consecutive hours and minutes,	28 hrs. 53 min.	22 hrs. 54 min.
Total distance run, in geographical miles,	339	226
Total number of revolutions made by the engine,	36436	24700
Total number of pounds of anthracite consumed,	101490	51800
Total number of pounds of ashes and clinker from the anthracite,	19700	8400
Total number of pounds of combustible consumed,	81790	43400
Per centum of anthracite in ash and clinker,	19·41	16·21
Pounds of anthracite consumed per hour,	3513·799	2262·069
Pounds of combustible consumed per hour,	2831·737	1895·196
Pounds of anthracite consumed per hour per square foot of grate surface,	17·569	15·708
Pounds of combustible consumed per hour per square foot of grate surface,	14·159	13·161
Pounds of anthracite consumed per hour per square foot of heating surface,	0·697	0·845
Pounds of combustible consumed per hour per square foot of heating surface,	0·562	0·708
Number of revolutions made by the engine per minute,	21·025	17·977
Steam pressure in boilers, in pounds per square inch above the atmosphere,	38·00	67·85

TABLE, (*Continued.*)

	WINOOSKA.	ALGONQUIN.
Steam pressure in main steam pipe, near the cylinder, in pounds per square inch above the atmosphere,	34·03	64·70
Proportion of the throttle valve open,	0·475	Wide.
Steam cut off at from commencement of stroke of piston,	0·705	0·126
Vacuum in condenser, in inches of mercury,	26 26	22·80
Barometer,	30·12	30·16
Mean gross effective pressure on piston, in pounds per square inch, by indicator,	34·721	28·055
Pressure of the steam in the cylinder at the end of the stroke of the piston, in pounds per square inch above zero,	22·50	11·53
Mean back pressure against the piston during its stroke, in pounds per square inch above zero,	1·71	4·35
Gross effective horses power developed by the engine,	1010·874	548·794
Pounds of anthracite consumed per hour per gross effective horse power,	3·476	4·122
Pounds of combustible consumed per hour per gross effective horse power,	2·801	3·453
Mean speed of vessel per hour, in geographical miles of 6086 feet,	11·737	9·869
Mean temperature, in degrees Fahr., of the atmosphere on deck,	38·55	41·00
Mean temperature, in degrees Fahr., of the engine room,	64·34	66·52
Mean temperature, in degrees Fahr., of the fire room,	90·27	98·65
Mean temperature, in degrees Fahr., of the injection water,	34 00	34·00
Mean temperature, in degrees Fahr., of the discharge water,	61·03	57·18
Mean temperature, in degrees Fahr., of the hot-well or feed water,	109·72	142·91
Difference between the rotary speed of the centre of pressure of the paddles and the speed of vessel, in per centum of the former,	20·48	22·93

Sugar.—Alvaro Reynoso's Cold Process.

From the London Journal of the Society of Arts, No. 683.

Messrs. Travers call attention to this process as follows: "Certainly no one can say that sugar manufacture is not advancing, when we have to chronicle in one year Fryer's concreter, the alcoholic process, (of which we hope to give details shortly,) and the cold process of M. Reynoso. True, neither of these inventions have as yet had any effect upon sugur making in general, but they also have not been tried. Without them, however, a point has been reached, when, with vacuum pans, centrifugal machines, *appareils à triple effet*, and other old in-

ventions and new applications, white sugar can be as cheaply made as brown, and when, were it not for the scale of duties, we should receive all our sugar in a fit state for immediate use. With regard to M. Reynoso's process, the following particulars are extracted from a paper read by that gentleman before the French *Académie des Sciences* and reported in the *Comptes Rendus* of that body. M. A. Reynoso commences by saying: 'The process for the treatment of saccharine juices, which I have the honor to submit to the Académie, is divided into two parts. 1st. Defecation. Chemists have long been occupied with the advantages that would result were aluminous substances used in sugar manufactures. Alum, sulphate of alumina, and alumina itself, in a more or less pure state, have been tried with more or less success in sugar manufactories. Evans has described in detail the way in which alum and the sulphate of alumina were used, and speaks of the good results that had been obtained in the English colonies. I myself have employed sulphate of alumina under different circumstances, but have seen that, side by side with considerable advantages, the use of this substance leads to serious inconveniences. Acid phosphate of lime has been used in Cuba since 1860, and particularly in 1863, in M. D'Aldama's works, by Mr. Swift, a distinguished American refiner, and I about that time described his process. I believe that I can now use alumina in a way to produce a defecation, perfect, from a commercial point of view, and that I at the same time succeed in eliminating hurtful substances. The substance I use is acid phosphate of alumina. After having put it directly into the cane juice, the mixture is treated with lime; free alumina and sulphate of lime are thus formed. The reactions resulting from acid phosphate of alumina, from alumina, from phosphate of lime, and from lime added in slight excess, do away with the coloring matters, azotised bodies, &c., in such a way that only a few of the salts are left that originally existed in the juice. This defecation may be compared to that produced by sub-acetate of lead, but it has not its inconveniences. 2d. Separation of the water. To evaporate the water contained in the purified juice, I employ *cold instead of heat*. I prevent in this way the numerous and complex reactions which, under the simultaneous influence of air and water, and heat coming between the different matters of which the juice is formed, cause the change in the color of the sugar. By means of a rapid cooling, produced in suitable machines, I change the juice into a magma—formed of a mixture of water reduced to the state of small pieces of ice, and of a syrup more or less dense, according to the conditions of the operation. To separate this mixture I have recourse to centrifugal machines, and I end the process by evaporating the syrup in vacuo. The details of the process will be found in my memoir.' This memoir has not yet been made public, and we shall await further particulars with some impatience. To give an opinion as to the value of the chemical part of the defecation would be premature, and it is only in practice that its value can be determined. With regard to the separation of the greater part of the water by freezing, the idea is so

simple, and yet so beautiful, that it cannot but excite admiration. It is well known that water when frozen rejects almost all alien substances, and that the ice even of a muddy puddle is pure, while the salt is driven out of frozen sea-water. Whether the cold process will pay, we cannot say, but M. Reynoso deserves every credit for the application of a well known principle to sugar making, and we may conclude by wishing that gentleman the success to which his efforts entitle him."

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, February 15th, 1866.

The meeting was called to order with the President, William Sellers, Esq., in the chair.

The minutes of the last meeting were read and approved. The minutes of the Board of Managers were reported as follows:

The Board of Managers have organized by electing Messrs. George Erety and W. Barnet Le Van curators for the ensuing year, and appointing the following Standing Committees:

1. *On Instruction.*

John F. Frazer,
Pliny E. Chase,
J. Vaughan Merrick,
Coleman Sellers,
Henry Morton.

2. *On Stocks and Finance.*

Frederick Fraley,
George Erety,
Washington Jones,
James S. Whitney,
Samuel S. White.

3. *On Elections and Resignations.*

O. Howard Wilson,
Percival Roberts,
Henry G. Morris,
Samuel Hart,
William J. Horstmann.

4. *On Publications.*

John H. Towne,
Fairman Rogers,
Henry Morton,
Coleman Sellers,
Samuel Sartain.

Donations were received from the Royal Astronomical Society and the Royal Geographical Society, London, England; the Canadian Institute of Toronto, Canada; the Mechanics Institute, San Francisco, California; the Bureau of Agriculture, Washington, D.C.; B. H. Latrobe and C. S. Smith, Baltimore, Md.; T. H. Leavitt, Boston, Mass.; and Charles E. Smith, Prof. John F. Frazer, Edward L. Wilson, and the Mercantile Library Company, Philadelphia.

The Various Standing Committees reported their minutes, and the Special Committee on experiments in steam expansion reported progress.

In default of the regular paper for the evening, a description was given, by Mr. J. Moore, of an ingenious contrivance by which the

various astronomical phenomena connected with the earth and moon, such as eclipses, phases, precession of the equinoxes, &c., were illustrated. This apparatus is called a Geoselenean.

The report of the resident Secretary, on new discoveries, inventions, &c., was then read.

Secretary's Report.

In a paper read before the London Microscopical Society, by F. H. Wenham, some curious and valuable facts are mentioned in connexion with the cause of certain fractures in glass. If a hard body, such as a piece of iron wire, is drawn with force over a plate of glass, and the latter is inspected with a microscope employing polarized light, a mark will be observed, much like the bur made on a leather bound book, by drawing over it the edge of a paper cutter. The particles in this line are compressed, and develop a strain which, of course, tends to produce a rupture. This will account for the very common breaking of glass tubes which have been cleaned by forcing through them with a wire, a piece of cotton waste or like substance. It is the wire which does the mischief, or if a piece of cane is used, this, by reason of its hard, silicious character, is equally destructive. A piece of soft wood, or some equivalent means, should be employed.

The action of the glazier's diamond is very similar to this, and if the glass is thick and is not broken after "cutting," the compressed particles will in time disintegrate and break up along the line, producing a double furrow, as may be seen by watching the process of polishing out such a scratch.

In a previous report it was mentioned that a M. Alvergniat had received a prize from the Société d'Encouragement pour l'Industrie Nationale, for the manufacture of Geissler tubes. At that time the Secretary had written to Mr. J. Queen, of this city, then in Europe, requesting him to obtain a set of these tubes from the manufacturer named. This had been successfully accomplished, and the large collection of tubes now exhibited was part of the assortment imported by Messrs. Queen & Co. These tubes certainly did credit to the award of the Society above mentioned, and to the skill of their constructor, being the most beautiful and even wonderful specimens of glass-blowing ever seen in this country. In some cases globes were seen within other globes, cemented, and filled with different rarefied gases. In others, spirals of glass tubes were seen within and filling globes in a manner which defied even conjecture as to the method of their introduction. The perfect regularity and precision of form in all parts was another noteworthy feature in these structures, regarding them simply in a mechanical point of view.

When the current of electricity from a Ruhmkorff coil was passed through these tubes, the effects of light and color developed were in many novel, and in all most beautiful. In the middle of one was seen a luminous emerald-green lily cup, (of fluorescent uranium glass,) into and over which streamed a flood of purple light; another contained at one end nitrogen, giving a reddish-purple light, in the middle sulphide of

carbon, giving white light in broad stratifications, each half an inch thick, which filled a globe of 5 inches, constituting the middle of the instrument; the other end, containing carbonic acid, (?) showed a rose-pink light. The different parts of the tube were united by the concentric globes before mentioned, and in these the white stratified light was broken into a starlike figure, tinged with purple in one case, and with pink in another, in a manner, the beauty of which cannot be described. Other tubes contained spirals of various forms immersed in fluorescent solutions, and developed with these every conceivable combination of colors and tints.

A set of tubes also contained some of Becquerel's phosphori, or sulphides of calcium, and of strontium variously prepared. These, after the momentary passage of the electric flash, or after exposure to daylight, continued to glow for some minutes with green, blue, and orange light.

It was also mentioned in a previous report, that very small Ruhmkorff coils had been manufactured at Paris. A specimen of these, imported by Messrs. Queen & Co., was present for inspection. The coil, with a battery to work it, and a set of Geissler tubes, was here contained in a box about the size of a common school dictionary, and could be furnished at the moderate price of $18.

In connexion with these Geissler tubes, the Secretary would mention an observation communicated to him by Prof. Rood of New York, which might be of value to those using them. The sealed ends of these tubes were covered with cement. This was required for insulation; without it the spark would sometimes enter the tube at this point and cause it to admit the air. One of the tubes in this collection had lost this insulation, and if used without it might have been spoiled.

The receipt for Schultze's white gunpowder has been published, from which it appears that this material is simply tri-nitro-celulose, or explosive pyroxyline prepared from sawdust (which has been washed in alkali and bleached) soaked in a solution of nitre and dried.

In connexion with this, attention was called to some little packages of paper, sent by Messrs. Queen & Co., a sheet of which, crumpled in the hand, lit, and thrown in the air, burned with a brilliant colored light,—red, green, yellow, &c., without smoke or ash. These consist of paper converted into pyroxyline by nitric acid, saturated with some flame-coloring salt, such as nitrate of strontia, baryta, &c., and dried. A description of these was published in the notes to "Faraday's Lectures on the Physical Forces." They form a pretty philosophic toy.

It may be well at the present time to mention, though the observation is an old one, that if a few fragments of chlorate of potash are thrown into dilute hydrochloric acid, small quantities of chlorine, mingled with hypochlorous acid, are evolved, which act as deodorizer or disinfectant.

From a paper read before the British Association, by Dr. B. W. Richardson, we learn, as the result of elaborate investigations, that ozone is present in pure air in the proportion of 1 part in 10,000. In excess it tends to develope congestive bronchitis in carnivorous ani-

mals, but has little effect on herbivorous, and deodorizes putrefying substances, checking putrefaction.

Antozone, on the contrary, produced among other things, by the breathing of animals, promotes putrefaction and developes diseases of that character. Air, even if purified from carbonic acid, is not wholesome without ozone, and as this is destroyed by intense heat, we can readily understand the evil effects produced by allowing a furnace for warming, to become red hot.

It is announced that the two light-houses at Havre will be lit with the electric light supplied by magneto-electric machines, manufactured by the Alliance Co., of Paris.

The following Committees were appointed by the President:

On Library.

Pliny E. Chase,
John C. Browne,
James Dougherty,
Fairman Rogers,
James S. Whitney,
John Redfield,
Henry Morton,
J. V. Merrick,
Charles Bullock.

On Arts and Manufactures.

William Adamson,
John H. Cooper,
Charles G. Crane,
Henry R. Lawrence,
C. Eugene Meyer,
Jacob Naylor,
Isidore Osorio,
Percival Roberts,
William G. Rhoads,
Samuel S. White.

On Minerals.

Clarence S. Bement,
Isaac H. Conrad,
John F. Frazer,
Emile Geyelin,
Theo. D. Rand.
Robert H. Lamborn,
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James Agnew,
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Facts about Peat as a Fuel. By T. H. Leavitt. 2d edition. Boston: 1866. 8 vo., pp. 168.

Facts about anything are always of interest to the student of nature,

and no one can say that any such may not be or become of importance in the arts. Facts in reference to fuel, in view of our present enormous consumption, and the tendency to monopolies in the supply, take precedence of those on almost any other subject in reference to their importance to manufacturers, and even to persons in general. The treatise before us presents a great number of well arranged and well expressed facts upon the subject of peat as a fuel, which we fancy will be, in a great measure, new to very many of its readers, and are well worthy of their attention. The origin and nature of peat, the modes of determining where it exists, of obtaining and preparing it for use, its general value as a fuel, and the particular circumstances under which its use appears to be especially indicated, are well set forth, and the result is a very useful and entertaining treatise, which would seem to have attracted much of the attention which it merits, since it appears that a second edition has been called for within nine months of the issue of the first.

Photographic Mosaics. Edited by M. CAREY LEA and EDWARD L. WILSON. Philadelphia: 1866. 18 mo., pp. 144.

This little work consists of a collection of small articles on subjects connected with photography, such as will be found valuable by amateur or even by professional photographers, and which would be difficult for any one to refer to as quickly as desirable unless thus collected and preserved. Several original papers by M. Carey Lea, Esq., who has earned for himself a well deserved reputation in this branch of art, and the valuable series of letters by Mr. Coleman Sellers to new beginners in the art, are added to the collection, and the whole forms a neat and handy little volume, which every photographer will find valuable to him in the prosecution of his labors.

The Celebrated Theory of Parallels.—Demonstration of the Celebrated Theorem Euclid I, Axiom 12; with appendix containing the philosophy of the demonstration, together with the partial refutation of Mr. Wm. Hamilton's philosophy of the unconditioned or infinite. By MATTHEW RYAN of County Tipperary, Ireland. Washington: 1866. 12 mo., pp. 10.

In a circular note sent with the pamphlet the author affirms that, "Besides wiping away the reproach of geometry, it acts as a barrier against atheism and infidelity." We therefore strongly recommend its attentive perusal to all whose geometry requires wiping clean from reproach, or who feel in danger of an attack from atheism or infidelity. But since its effect has been to render Bertrand absurd and Prof. Henry unphilosophical, (p. 4,) we rather incline to adhere to the Smithsonian Institute and the Coast Survey, and "shrink from expressing an opinion." Let every one read and make his opinion for himself, expressing it if he dare.